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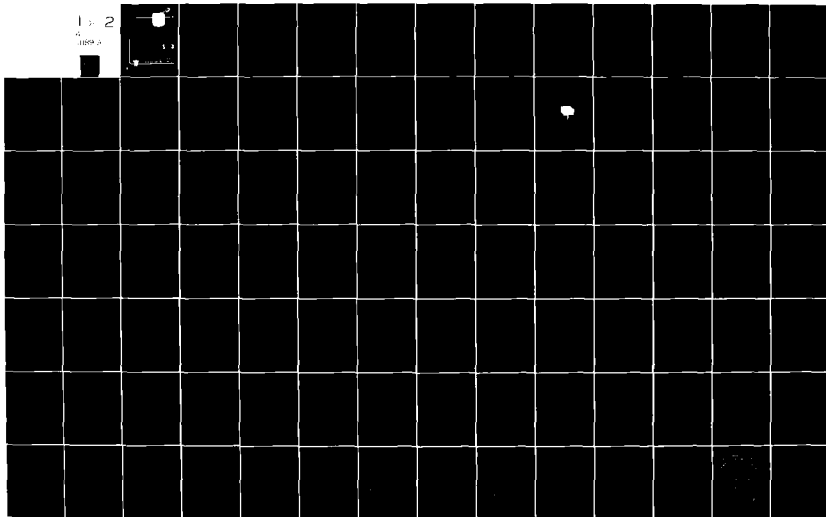
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STUDY  
PROJECT

JUNE 1982

THEATER LEVEL WAR GAMES

by

LIEUTENANT COLONEL GERALD L. PAULER  
CORPS OF ENGINEERS

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Item 20. (Continued)

Conclusions: Many studies have been made over the last 10-12 years which seek to improve analysis (modeling) conducted within and for the U.S. Department of Defense. Within the U.S. Army many things are currently being done to improve the development and use of models. The Army modeling community is becoming better coordinated and more directed than ever before. Still, many things remain to be done. Possible improvements include; (1) annual, independent assessments of models, (2) production of an annual catalog of Army Models with a review and analysis section, (3) increased dialogue between Army personnel concerned with models and the wider technological-scientific-academic community, (4) increased centralized management of data, and (5) design of a proactive component to modeling activities for future effort and direction.

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US ARMY WAR COLLEGE  
MILITARY STUDIES PROGRAM

THEATER LEVEL WAR GAMES

BY

LIEUTENANT COLONEL GERALD L. PAULER  
CORPS OF ENGINEERS

STUDY ADVISOR  
MR. FREDERICK F. McCLINTIC

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## ABSTRACT

**AUTHOR:** Gerald L. Pauler

**TITLE:** Theater Level War Games

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**Scope of Study:** This study examines the use, development and improvement of theater-level models. It traces historical developments with emphasis on issues and problems of the most recent past. Modeling efforts within the U.S. Army are discussed as well as examples of Contractor activity. Selected theater models are presented with a detailed treatment of the McClintic Theater Model and its use by the U.S. Army War College. The future of war gaming is explored with reference to emerging requirements of an advanced technology force.

**Conclusions:** Many studies have been made over the last 10-12 years which seek to improve analysis (modeling) conducted within and for the U.S. Department of Defense. Within the U.S. Army many things are currently being done to improve the development and use of models. The Army modeling community is becoming better coordinated and more directed than ever before. Still, many things remain to be done. Possible improvements include; (1) annual, independent assessments of models, (2) production of an annual catalog of Army Models with a review and analysis section, (3) increased dialogue between Army personnel concerned with models and the wider technological-scientific-academic community, (4) increased centralized management of data, and (5) design of a proactive component to modeling activities for future effort and direction.

## PREFACE

This study was conducted as part of the U.S. Army War College Military Studies Program in coordination with Colonel Raymond M. Macedonia and Mr. Frederick F. McClintic of the Department of War Gaming. The program is designed to provide a special educational opportunity to enhance existing knowledge within a particular area-of-interest. As such, it succeeded admirably.

The program also requires that a practical contribution be made to the U.S. Army. During the final construction and writing of this study, I often thought that its value or contribution would be measured by the people who read it and, perhaps, find something of use in its pages. For example, I have imagined Brigadier General Quinn, the new Deputy Director of the Concepts Analysis Agency (CAA) picking up this paper for the first time. My fanciful criteria for a successful contribution then, is for him to spend more than just a few minutes with it, or to refer back to it, and to see something of value. In any event, his confidence and helpful comments are greatly appreciated.

There are many other people to thank for making this study possible. Lieutenant General Stone, Commander, Combined Arms Center and Ft. Leavenworth, was very kind in allowing me wide access to personnel, activities and related meetings at Fort Leavenworth. Toward the end of my research and travel, he received my In-Progress Review with interest and provided many detailed comments. My appreciation also extends to several of his staff, especially to Colonel Robinson, Director of the Army Models Improvement Program Office (AMMO) for his contributions to Chapters III and VIII. Colonel West, Director of the Combined Arms Studies and Analysis Activity (CASAA) was very helpful in obtaining completed surveys for various models.

Correspondence with Brigadier General Elton, Commander, 9th Infantry Division was also helpful and led to a productive visit with Mr. Bob Jolly and others concerned with modeling at Ft. Lewis.

Conversations with Dr. Sam Parry, Dr. James Taylor and Captain Ted Farmer at the Naval Postgraduate School (NPS) also provided special insights and are appreciated. A special thanks is due many people at the Army War College — Colonel Clark, Colonel Saul, Colonel Macedonia, Colonel McGurk, Mr. Fred McClintic, Colonel Franz, Colonel Felter and Captain Aaron.

A final thanks goes to Mr. Seymour Goldberg, Training and Doctrine Command (TRADOC) and to Tony Quattronami, Office of the Joint Chiefs of

Staff/Studies Analysis and Gaming Activity (OJCS/SAGA).

There were many other people and organizations, such as Colonel T. N. Dupuy (USA, ret) and the Combat Developments Experimentation Command (CDEC), that would have been useful to visit. However, events of the USAWC-82 year soon closed in on the reseach and travel schedule.

My "caveat" to this study is that any mistakes or omissions are due to the nature of the research project. Near the end of my research I could see whole new beginnings and fruitful areas of exploration that had not been allowed for in my original time schedule.

## CHAPTER I

### INTRODUCTION

"Now," said Rabbit, "this is a Search, and I've organized it . . . ."

"Done what to it?" said Pooh.

"Organized it. Which means . . . well, it's what you do to a Search when you don't all look in the same place at once."

. . . From The House at Pooh Corner  
By A. A. Milne

This study describes current theater-level war gaming efforts being conducted by and for the U.S. Army. There are eight chapters. Chapter One defines the purpose, scope, methodology and objectives of the study. The purpose includes the determination of the current status of Army modeling efforts and examination of selected theater-level models. A primary objective is to connect elements of the literature from the late 60s to the emerging efforts of the 80s. Thus, current theater-level war gaming efforts may be viewed in relationship to many modeling issues and problems.

War gaming literature forms the basis of Chapter Two. Important books, model reviews, workshops, contract studies and Department of the Army documents are discussed. A stage is set for understanding issues and problems of the Army Model Improvement Program (AMIP) which is the subject of Chapter Three. Management and organizational structures are examined relative to the wider modeling community. Since the focus of

the study is on theater-level war games, AMIP and Combined Arms Study and Analysis Activity (CASAA) relationships to the Concepts Analysis Agency (CAA) are explored.

A general discussion of contractor effort is covered in Chapter Four. Chapter Five contains an examination of selected theater-level models. Several aspects and features of the McClintic Theater Model (MTM) are contained in Chapter Six. Its use by the U.S. Army War College is discussed along with its current development.

An arrow to the future is provided by Chapter Seven. Special modeling needs of the High Technology Test Bed/High Technology Light Division (HTTB/HTLD) are examined. The need for forward, proactive thinking is discussed along with possible initiatives that can be taken.

Finally, Chapter Eight ends the study with summary thoughts, recommended future research and some thought-provoking specific actions for implementation. Among these are suggestions for: professional development of the military element of the modeling community; model and data base requirements, future organization structures and relationships; and, urgent present needs. Included in this last suggestion is the publication of an annual Department of the Army Models Catalog. Such a catalog could develop beyond a tabulation into a modeling review and analysis document that would track, on a yearly basis, the development and use of all models used by the U.S. Army.

#### Subject Area and Objectives

The subject area concerns the use of computer models for study and analysis. Modeling activities undertaken by and for the U.S. Army are examined with focus on theater-level war games.

Objectives of this study are:

- (1) To describe current Army efforts on theater-level war games.
  - a. Describe Army organizations involved in modeling.
  - b. Discuss selected contractor activity.
  - c. Discuss improvement efforts.
- (2) Examine catalog/review/evaluation efforts.
  - a. Examine Studies, Analysis and Gaming Agency (SAGA) and Concepts Analysis Agency (CAA) catalogs/tabulations.
  - b. Examine periodic review documents.
- (3) To discuss the war gaming/modeling literature.
  - a. Defense technical Information Center (DTIC) Documents/Texts/Correspondence.
  - b. Perceived modeling issues/problems.
- (4) To discuss features of the McClintic Theater Model (MTM).
  - a. The FORTRAN and PASCAL versions.
  - b. The top-down structure.
  - c. Adoptions, joint service use, Tactical Command Readiness Program (TCRP).
  - d. Results of AWC play with NATO and SW Asia scenarios.
- (5) To examine theater-level war games other than MTM.
- (6) To examine High Technology Test Bed modeling needs.
  - a. The future of war gaming.
  - b. Unique modeling features required by an advanced Technology Force.
- (7) To present conclusions from research and make recommendations that contribute to dialogue in the war gaming community.

### Purposes and Preliminary Results

The purposes of this study were:

- (1) To determine status of the Army modeling effort with focus on theater-level war games.
- (2) To examine specific models with emphasis on the McClintic Theater Model (MTM).
- (3) To obtain recent information on catalog/review/evaluation efforts.
- (4) To describe the most significant elements from the literature since about 1970.
- (5) To examine the organizational structure for Army modeling.
- (6) To examine HTTB/HILD modeling needs.
- (7) To determine/discuss modeling issues/problems.

Preliminary results of this study yielded the following points and recommendations:

#### (1) Points

- a. Relationships between the CSA, VCSA, SPMO, TRADOC, AMIP and DUSA(OR) require continuing clarification relative to the management of Army models.
- b. In 1971, a recommendation was made to create a DA level scientific advisor for studies and models. Among major responsibilities was the coordination of technical reviews with DUSA(OR).
- c. No previous methodology existed for evaluation of Army models prior to the 1971 study.
- d. An annual Army models catalog could aid development of models, elimination of models, model improvements and evaluation of previous and on-going modeling activities.



e. Army personnel connected with studies and analysis (modeling) have not been highly involved in gaming workshops and professional meetings such as those held by ORSA and TIMS. Higher level decision makers and users have been notably absent.

f. Modeling development has exceeded the Data Base Management System effort. In the future, models will require increasing amounts of data, especially as USAF modules are incorporated into Army models and specific test data and data voids are integrated. Consistent data management will require increased awareness and coordination among decision makers at the different MACOMS involved in AMIP efforts.

(2) Recommendations

a. Perform thorough, annual, independent evaluation of model usage and development.

b. Continue emphasis and support of the AMIP in order to achieve an initial, tested integration of the model hierarchy by the end of 1983.

c. Create a cataloging element within the Army modeling community to provide a description and classification scheme for the production of an annual Army Models Catalog.

d. Increase dialogue and exchange of information between model builders, data producers and model users with analysts in the Army and the wider technological-scientific community. This can be accomplished by increasing membership in professional societies and attendance of professional conferences by Army personnel.

e. Send a message, prepared by the AMIP Director, to the DUSA(OR) requesting coordination plans for Army models and centralized agency data management. An initial step could be review of the 1971,

1975, and 1979 model review - reports which contain specific proposals for DUSA(OR) coordinating activity.

f. Design a proactive component to studies and analysis (modeling) activities by creating initiatives for future efforts. Critical areas are the DBMS, data voids, Army and Air Force cooperation, and basic theories of future combat (e.g., year 2000).

#### Scope of Study

This study treats current and developing Army efforts in war gaming with focus on the McClintic Theater Model. Modeling issues and problems of organizations such as CASAA, AMIP, HTTB/HTLD, CAA, OJCS/SAGA and others are presented. Theoretical and practical considerations posed by various organizations such as the Naval Post-graduate School are also discussed. Cost considerations are not included. The emphasis is on describing what has been done in the recent past, current efforts and possible future directions.

#### Methodology

The study began with a review of war gaming literature in order to weave a connective thread from about 1970 to the present. Interviews and correspondence were established with organizations and personnel involved in Army modeling issues. Detailed study and play of MTM was accomplished and an examination of HTTB/HTLD modeling needs was made.

Travel included trips to the Combined Arms Center and Ft. Leavenworth, OJCS/SAGA, the Naval Post-graduate School and TREM, Fort Lewis, Concepts Analysis Agency, BDM Corporation and to an Operations Research Society of America/The Institute of Management Science (ORSA/TIMS) conference in Detroit. During the conference, I met with several contract personnel including Dr. Seth Bonder, President of Vector Research Insti-

tute (VRI). There were other organizations and personnel that I would like to have visited but was unable to due to events of the USAWC-82 year. I did receive several documents through the mail and had several informative phone conversations with personnel that were not on my travel schedule.

A detailed survey form was used to gain specific information on several theater-level models. An abbreviated survey was also conducted into the use of the Student War Game Model at the U.S. Army War College.

## CHAPTER II

### SURVEY OF THE LITERATURE

"Operations Research may be regarded as a branch of philosophy; as an attitude of mind towards the relation between man and environments; as a body of methods for the solution of problems which arise in that relationship."

... From OR Journal, 1958  
By M. G. Kendell

War games have a rich history yet their exact origin is unclear.<sup>1</sup> Possibly they originated as part of the training or planning involved in war. Consideration by a commander and his staff of a few scribbles in the sand may have constituted the first war game.

Chess-type war games were used during the 1700s. In 1811, Von Reisswitz, the Prussian War Counselor at Breslau, used a scaled terrain model with troop symbols for war games. His son, Von Reisswitz, Jr. is considered the "father" of modern war gaming.<sup>2</sup> He made refinements in scale and used red and blue figures to represent opposing forces. He also provided rules of procedure, introduced collection of intelligence and used scenarios for game starts. Specially prepared dice were used to simulate random outcomes of battlefield events. When Von Meffling, Chief of the German General Staff in 1824, saw an exhibition of the game he exclaimed:

It is not a game at all! It's a training for war! I shall recommend it most emphatically to the whole army.<sup>3</sup>

Work with war games continued in Germany throughout the 1800s with

varying degrees of rigidity in game structure. Then, prior to World War I, war games were used extensively by the Germans for development of military plans. Several other countries began using war games before and during World War II and their popularity has increased ever since. By 1960, developments with computers made it possible to carry out several versions of a game with many detailed computations. These early games were often called man-machine-games since the computer was referred to as a computing machine.

Dramatic evolutionary steps have been made over the last 20 years in computer technology. Computers are now closely associated with models. Along with an increasing level of weapon system complexity, computer models (war games) have also become increasingly complex. Their present use extends well beyond their simple beginnings as training and planning tools.

#### Model Dimensions and Taxonomy

During 1977, an investigation into the many problems of combat modeling at the theater-level was held at Leesburg Virginia.<sup>4</sup> This meeting represented a first attempt to look at all of the major factors pertaining to the development of theater-level models. The meeting's breadth of coverage thus brought to the surface a multitude of problems requiring attention. This macro approach was considered to be a necessary path to attacking finer points of methodology and technique.

A repeated issue during the meeting was the need for a "theory of combat" or for a better understanding of the "phenomenology of combat." Three basic dimensions of modeling were defined as:

- (1) Technique

- a. Military exercises

- b. Manual war games
  - c. Computer assisted war games
  - d. Analytic/Computer games (analytic models, simulations)
  - e. Interactive (or player-assisted) computer games
- (2) Scope
- a. Global and theater-level
  - b. Major engagement or battle
  - c. Local engagement, "many-on-many-units"
  - d. Local engagement, "one-on-one" duel
- (3) Application
- a. Force Planning
  - b. R&D planning, management and evaluation
  - c. Operational planning and evaluation
  - d. Training and education

These dimensions are shown in matrix form by Figure 1.<sup>5</sup> Contrast this matrix with the gaming spectrum and characteristic trends shown in Figure 2.<sup>6</sup> While these figures are important to the development of a taxonomy of military models, they are not descriptive either of the level of model complexity or of the influence of the players. For example, a computer-assisted (computerized) theater-level simulation may have an interrupt capability that makes it similar to a computerized theater-level war game. Additionally, there are several overlaps such as an interactive computer-assisted war game. Nevertheless, the figures represent good ways of viewing the many uses and purposes of models.

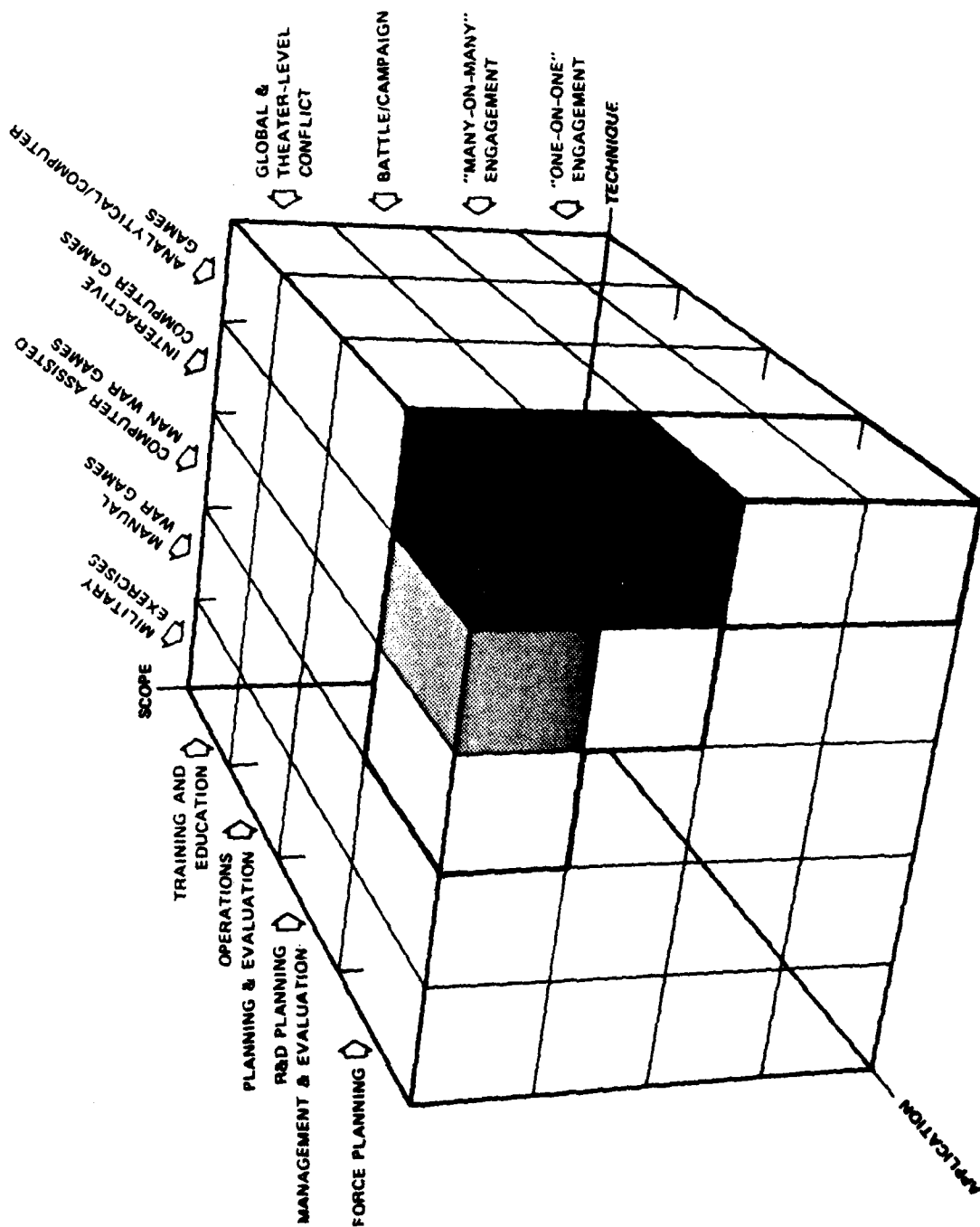


Figure 1 MODEL DIMENSIONS AND TAXONOMY

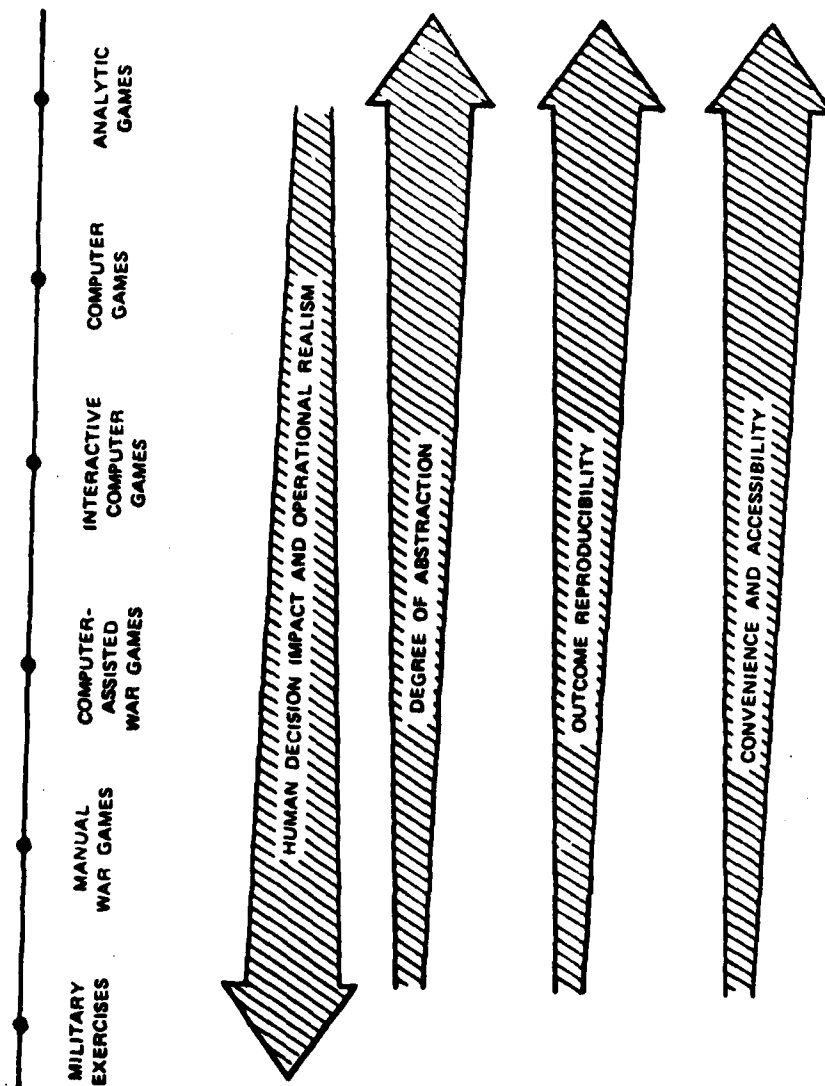


Figure 2 GAMING SPECTRUM AND CHARACTERISTIC TRENDS



### The Modeling Community

Lawrence Low describes the list of attendees at the 1977 Theater-Level Gaming and Analysis Workshop for Force Planning to be from the following three distinct communities:

- (1) Government (defense and defense-related activities: U.S. and allied)
- (2) Contractor (U.S. and foreign)
- (3) Academic (government and private, U.S. and foreign)<sup>7</sup>

Within the government are formed two user categories. One is the decision/policy maker. The other is the advisory and analytical staff. A further break-out is provided by Dr. Frank Kapper in Figure 3, which shows model design, development and data base components of the modeling community.<sup>8</sup>

Organizations which make up the modeling community within the U.S. Army are shown in Table I. Note that although the Army Models Improvement Program (AMIP), Management Office (AMMO) is shown under the U.S. Army Training and Doctrine Command (TRADOC) it is chartered by HQDA. The Combined Arms Center and Fort Leavenworth is the TRADOC executive agent for this program.

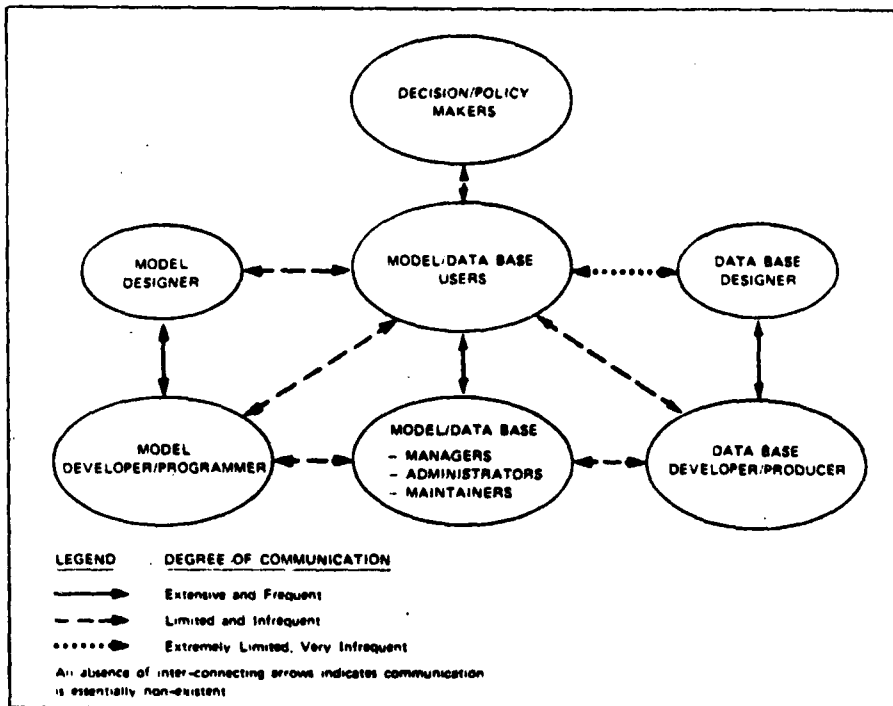


Figure 3 MODELING COMMUNITY RELATIONSHIPS

TABLE I

ARMY STUDIES AND ANALYSIS COMMUNITY ORGANIZATIONS

---

HQDA

Office Deputy Under Secretary of the Army for Operations  
Research (DUSA(OR))  
Study Program Management Office (SPMO), OCSA  
SELCOM (Study Program Coordination Subcommittee)  
Technical Advisor Office, ODCSOPS  
Advisor for Research, Development and Acquisition, ODCSRDA  
Research and Studies Office; Human Analysis Team, ODCSPER  
Study Management Office, ODCSLOG  
Red Team, OACSI  
Program Analysis and Evaluation (PA&E), OCSA

SSA/FOA

Strategic Studies Institute (SSI)  
Concepts Analysis Agency (CAA)  
Army Nuclear and Chemical Agency  
Army Research, Development and Acquisition Information  
System Agency  
Logistics Evaluation Agency  
Army Research Institute (ARI)  
Military Personnel Command  
Engineer Studies Center

Major Commands

US Army Europe  
US Army Intelligence and Security Command  
US Army Communications Command  
US Army Forces Command

US Army Training and Doctrine Command

DCS, Combat Development — Analysis Directorate  
TRADOC Systems Analysis Activity (TRASANA)  
Combined Arms Combat Development Activity  
Combined Arms Studies and Analysis Activity (CASAA)  
Army Models Improvement Program Management Office (AMIP/AMMO)  
Logistics Center  
Admin Center

TABLE I ARMY STUDIES AND ANALYSIS COMMUNITY ORGANIZATIONS (Continued).

---

Schools/Centers

- Armor
- Artillery
- Air Defense
- Infantry
- Aviation
- Engineer
- Transportation
- Quartermaster
- Missile and Munitions
- Intelligence
- Signal
- Military Police
- Ordinance and Chemical

US Army Materiel Development and Readiness Command (DARCOM)

- Battlefield Systems Integration Directorate
- Systems Analysis Division
- Armament Materiel Readiness Command
- Communications and Electronics Materiel Readiness Command
- Missile Materiel Readiness Command
- Tank-Automotive Materiel Readiness Command
- Troop Support and Aviation Materiel Readiness Command
- Armament Research and Development Command
- Aviation Research and Development Command
- Communications Research and Development Command
- Electronics Research and Development Command and Harry Diamond Laboratories
- Mobility Equipment Research and Development Command
- Missile Research and Development Command
- Natick Research and Development Command
- Tank-Automotive Research and Development Command
- US Army Materiel Systems Analysis Activity (AMSAA)
- US Army Management Engineering Training Agency (AMETA)
- Depot System Command
- Inventory Research Office
- Logistics Studies Office
- Logistics Control Activity
- Security Assistance Center
- Procurement Research Office

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### Problems and Issues

Several recent publications discuss problems and roles of models in defense decision making.<sup>9,10,11</sup> While there is considerable overlap in their coverage, they tend to complement each other in their identification of major issues such as:

- (1) Professional responsibility for model-building activity (identification of individuals involved in study and analysis)
- (2) Standards and rules for model builders and gamers (management and overall direction)
- (3) Professional communication (coordinated efforts between agencies, contractors, etc.)
- (4) External recognition and professional review
- (5) Theory and supporting data (the need for a better understanding of modern combat and a data base management structure)
- (6) Validation of models<sup>12</sup>

Recommendations have been specific to improving standards, stewardship and performance.<sup>13</sup>

A recent GAO report directed its recommendations to DOD and to the Congress. Appendix IV to the report contains a DOD response and a GAO rebuttal which illustrates an entirely separate problem or issue. A story, which was told to me as I was conducting my examination of Army models, is revealing to the nature of this problem.

There once were two farmers who planted their crops. Shortly after planting their seeds, one farmer dug up the seedlings to see how they were doing. As his plants continued their struggle for growth they were constantly interrupted to "see how they were doing."

The other farmer, having planted his seeds properly, stood back to observe their growth into maturity.

This simple story has continued to amuse me ever since. At first I was sympathetic to the analyst's complaint that his work was complicated by a continuing investigation and review. There is, of course, another viewpoint — perhaps the crops have not been "properly" planted.

A 1975 study by J. A. Stockfisch concentrates on the imbalance between theoretical and empirical endeavor in DOD study and analysis.<sup>14</sup> Further comments by Stockfisch at the 1977 theater-level workshop decry the need for combat theory and better data. Stockfisch commented:

. . . several times during this meeting I've found myself sort of reminiscing like Prince Andre, saying to myself 'What are these people talking about? Does it make any difference.'<sup>15</sup>

#### Review of Army Analysis

A recent special study group report, chaired by Mr. David C. Hardison, present Director of CAA, gives a basic review of analytic resources, organizations and procedures.<sup>16</sup> Its central thrust, philosophy and goals were approved for implementation by the VCSA on 22 March 1979.

CAA was assigned to the DA staff for analytic support to HQDA staff with an enlarged mission to include personnel/manpower and logistical analysis. Also approved was an increase of analytical capability at CACDA, a Study Program Coordination Committee (SPOC) subcommittee to the SELCOM and an enlarged Study Program Management Office (SPMO).

This review also set up a specific outline and plan for implementation of an Army model hierarchy. It identified major concepts which have now evolved as shown by Figure 4. The hierarchical concept is to tie in models across the application spectrum as well as along the scope axis (different levels from theater to "one-on-one"). Specific computer modeling techniques used for each of these purposes and applications are also to be compatible.

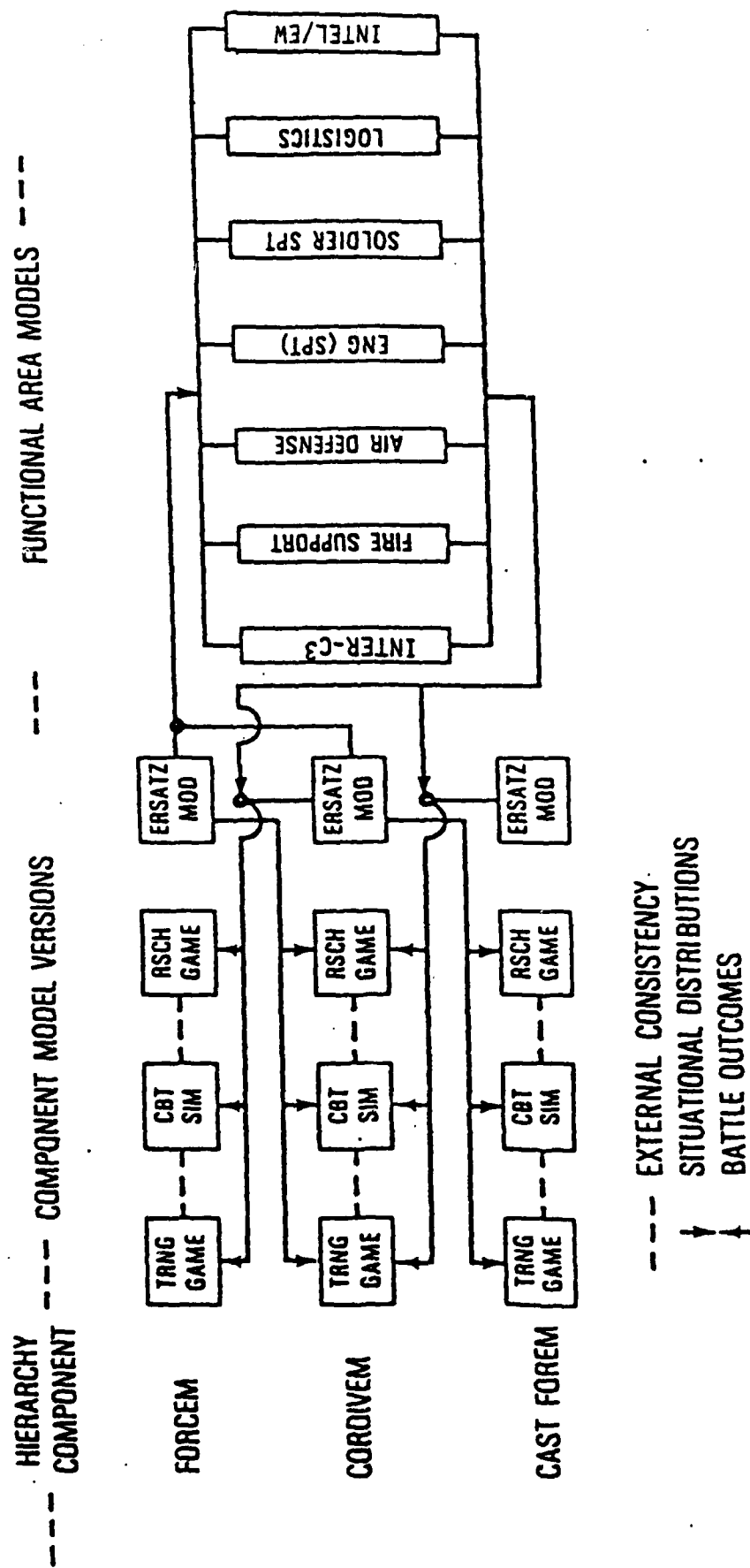


Figure 4 THE HIERARCHICAL CONCEPT OF ARMY MODELS

The basic structural concept for such a lash up is shown by Figure 5. This concept, along with other proposed actions of the review, constituted a major step forward in development of the Army's analytic capability and coordination. Many of its recommendations pertaining to improvements in models, regulations, analytic personnel and organizations are still being implemented today.

Proposed actions for a quality assurance program for models were:

- (1) Agencies and MACOMS should insure that programs are partly self-initiated (at least 10 percent) and provide adequate resources (at least 15 percent of program) for methodology development.
- (2) Assure that agency/activity label is affixed to study reports and that principal authors and significant contributors are identified by name on the reports.
- (3) Continue (or initiate) prepublication internal peer review.
- (4) Begin a SPMO program of external peer review.
- (5) Institute measures for study sponsor to feed back to study doer information on strengths, weaknesses and utility of study products.
- (6) Each major analytical organization can make use of a distinguished Board of Visitors, with members from both within and outside the Army to periodically review its work program and operations.
- (7) Hold periodic conferences of the senior members of the Army analytical community to identify problems within the community and suggest corrective action.
- (8) Orient the Army Operations Research Symposium so as to foster communication, exchange studies, and especially recognize work of high quality.



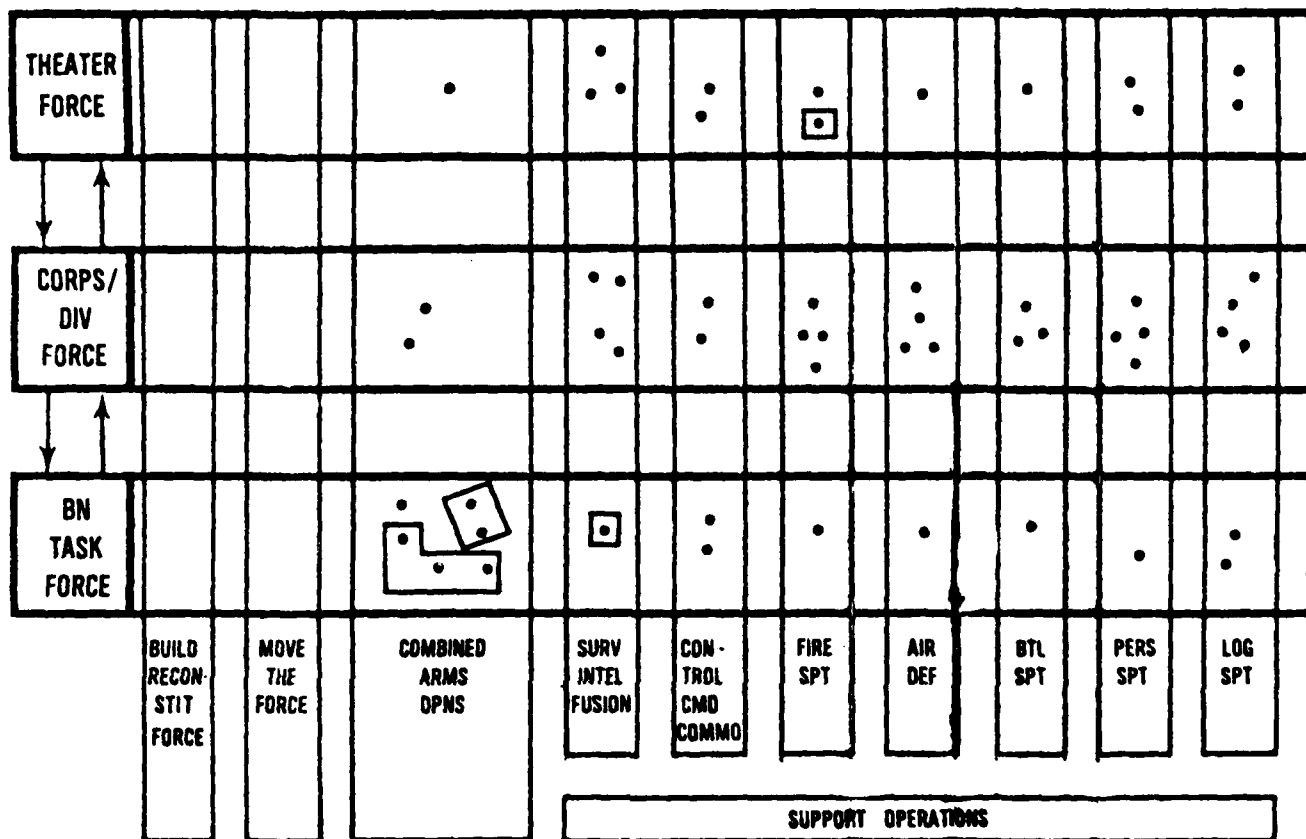


Figure 5 BASIC STRUCTURAL CONCEPT OF LASH-UP

### Model Reviews

In 1975 a review of models, with emphasis on the division level, was conducted by Mr. Phillip Louer and others.<sup>17</sup> Its purpose was to define Army requirements, evaluate models with respect to requirements and to provide guidance for improvement and future development. Adequacy and efficiency of the Army's family of models was of primary concern. Because of the lack of centralized model control, management and development problems contributed to inconsistency and redundancy.

The study also presented the concept of a hierarchy of models and discussed the merits of interactive gaming versus total simulation. Several division problems cited by the study. Systems for maneuver units, direct support and non-divisional support all required functional evaluation. These systems are directly linked to requirements for model coverage and performance.

Out of 15 candidate models identified as pertaining to division level operations, the following were selected for review: DIVWAG, DIVOPS, DBM AND DIVLEV. Also included were JIFFY, LULEJIAN I, CEM IV, AND DACOTAH. Functional models such as COMMEL (Communications), ADVICE II (C<sup>2</sup>) and DIVSIFT (TOS) were also tagged for analysis for their fit into the division models.

In December 1970, a steering committee, which included Dr. Payne, then Deputy under Secretary of the Army (Operations Research), appointed an ad hoc committee to review selected Army models.<sup>18</sup> The final report, rendered in May 1971, was chaired by Dr. J. Honig, OAVCSA, with members, R. Blum, Major H. Holland (Secretary), D. Howes (STAG), D. Lester [ODUSA(QR)], K. Myers (AMSAA), and R. Zimmerman.<sup>19</sup> Their primary acknowledgements were to the Research Analysis Corporation (RAC) and the

Strategy and Tactics Analysis Group (STAG). Dr. Seth Bonder, (VRI), Dr. J. Bruner (RAC), Dr. P. Lowry, Dr. Gordan Clark and Mr. Walter Eckhart were acknowledged for their assistance. Dr. Mader was cited as the author of an appendix on movement rates and co-author of an appendix on firepower scores.

Since no previous methodology existed for evaluation of Army models prior to this 1971 study, it defined some steps toward such a goal. Models were classified by type and command level. They ranged from war games to computer simulations for theater and corps/division levels. All battalion level models were total simulations: DYNTRACS, IVA, CARMONETTE, and BONDER. The range and level of the others are shown in Table II.

Criteria for evaluating models was based on validity and utility.

Criteria for evaluation were:

- (1) Validity of the model.
- (2) Logical consistency.
- (3) Mathematical correctness.
- (4) Degree of real life represented.
- (5) Analytical visibility of the model.
- (6) Ability to answer questions.
- (7) Responsiveness.
- (8) Efficiency.

TABLE II  
Selected Models, 1971

WAR GAMES		SIMULATION	
Manual	Computer Assisted	Player Assisted	Total
JIFFY TBM/TWGM TQGM (QUICK)	THEATERSPIEL (not operational- superseded by CORPS BM)	TARTARUS	ATLAS (1967) (non-nuclear linear-FEBA)
TBM-DOM	CORPS BM DIV BM ADVICE	LEGION DIVTAG EINFALL	

No theater models were found in 1971 which were able to address force mix or employment problems. Use of the ATLAS model was deemed questionable and TARTARUS did not provide meaningful results.

Division level war games were considered more useful because of the difficulty of simulating command decisions. Possible tie-ins were suggested for DIV BM and a theater-level game. LEGION and DIVTAG were recommended for scraping in favor of DIVWAG, a game under development.

The battalion level game, DYNIACS was considered to be the most realistic Army model in 1971. Its high resolution features allow research into weapon systems and small unit combat interactions. CARMONETTE was the preferred production model. It was concluded to not maintain IVA as a preferred model.

The study discussed the need for lower level models to be integrated with higher level models.

Serious problems were also found with input data. The most serious problem was for target acquisition, suppression and neutralization data.

Six areas were considered the most important to future research for improving Army models.

- (1) Problems of Aggregation.
- (2) Target Acquisition.
- (3) Night Operations.
- (4) Information Processes.
- (5) Suppression and Neutralization.
- (6) Decision Processes.

Mention of C<sup>3</sup>I or electronic warfare was not made although item 4 mentioned developmental efforts to increase the effectiveness of tactical units through automated information processing.

Along with an inadequate DA organization, the study found inade-

quate documentation concerning the models themselves. In many cases no technical review, validation or evaluation effort surrounded the model development and use. The study made the following recommendations:

- (1) Reduce the number of models retained.
- (2) Employ personnel more effectively.
- (3) Require detailed, independent, review of retained models.
- (4) Validate models against historical fact or with other models.
- (5) Accomplish more complete documentation to include all implicit rationale and subject results to independent technical review.
- (6) Determine model applicability to analytical questions in detailed model reviews.
- (7) Maintain acceptable models.
- (8) Before building a new Army model specify objectives and an examine existing models.
- (9) Appoint an Army Scientific Advisor for Studies and Models with an office of 4-5 professionals.

The advisor would report directly to the AVCSA and coordinate with the coordinator of Army Studies. Responsibilities would include coordination of all Army models, identification of data requirements and facilitation of needed research. Status reports to the AVCSA on models, developments, research and data collection would also be made.

The recommendation for validating models is a difficult one. Historical fact does not exist for validation of a model of current and future warfare. According to James Taylor of the Naval Post-graduate School, it is misleading to use one model to validate another model.<sup>28</sup>

I believe that what is needed or desired is model compatibility. Each one is based on the same basic data set or subset.

Thus, as envisioned in hierarchical concepts, a battalion level war game could produce detailed results for the battalion that would be compatible with the aggregated results obtained from both a division level and a theater-level war game. Even though the theater-level war game may use aggregated inputs for the battalions effectiveness in combat the results could be "validated" in detail by the battalion level war game.

The use of the term validation itself is somewhat misleading in the context of current use of Army models. No past event exists for validation of models unless we are attempting to model a past event. Even then, the model can only be partially validated depending upon the accuracy of historical records and general agreement as to the accuracy by the intellectual community, i.e., Scientists, Historians, Analysts.

The 1971 report did not consider nuclear operations, logistic support models, air defense or fire support beyond the close combat zone.

As for hierarchy of models, no links between the existing 1971 model levels were found. How successful or unsuccessful use of a particular model had been with respect to how decisions were then made in the Army was unclear. Examination of the Army decision making process was considered beyond the scope of the study.<sup>21</sup>

The study listed five desirable characteristics for the theater level models:

- (1) Force Planning and Requirements.
- (2) Force Structure and Mixes.
- (3) Logistic Support.

(4) Force Employment.

(5) Training.

ATLAS, TQGM and JIFFY are based on WW II and Korean data about division movements, casualties and ammunition expenditure. They use aggregated firepower scores and force ratios to determine engagement results.

THEATERSPIEL, TCM and TARTARUS attempt more detail and finer resolution by fitting together detailed component processes. TCM appeared to be the best theater-level model at the time, although it needed to be checked against a war game.

The committee felt that a theater-level war game capability was needed to serve as a research tool to advance the state-of-the-art as well as to improve simulation capability.

Adequate measure is required for firepower, mobility, C<sup>3</sup>I and logistics. In low resolution models, aggregated effects are accounted for by the use of force ratios and firepower scores for assessing casualties and movement.

Measurement of firepower effects is hindered by lack of historical data on many new weapons. Other aspects of combat such as mobility, C<sup>3</sup>I and logistics also need to be accounted for their influence on force ratios. The committee concluded that firepower score techniques were obsolescent at that time and improved means for assessing engagement outcomes was needed.

One approach suggested is the use of tables developed from output of high resolution models. Thus a theater-level war game would use as input, data developed from lower-level models. Because the firepower score approach lacks ability to account for individual weapons and



synergistic weapon effects the problem of aggregation was cited as the highest priority research area. The aggregation problem was followed by problems with target acquisition, night operations, information processes, suppression and neutralization and the decision process as other high priority research areas.

In June 1971, Drs. Shubik and Brewer completed a questionnaire for models, computer machine simulations, games and studies.<sup>22</sup> The purpose was to examine DOD models and to provide a description and classification scheme for a catalog which would: provide model information, aid construction of new models and aid evaluation of previous and current activities.

One of the results of this 1971 effort was their publication in 1979, of The War Game: A Critique of Military Problem Solving. Since most of its references are pre-1978 it did not foresee the major developments that have occurred since. It did, however, point to the fact that the really creative, difficult work in the field of operations Research (modeling) has only begun.

In the next chapter, one of the most recent and significant Army modeling efforts toward a hierarchy of models is described.

## CHAPTER II

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3. Weiner, p. 8.
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9. L. J. Low (Editor), "Theater-Level Gaming and Analysis Workshop for force Planning, 27-29 September 1977, Vol. I: Proceedings." SRI International.
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12. Brewer and Shubik, pp. 223-224.
13. Brewer and Shubik, pp. 259-326.
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16. U.S. Department of the Army, Review of Army Analysis, Vol. I: Main Report, pp. 4-5.

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## CHAPTER III

### ARMY MODELING EFFORTS

This chapter discusses the background to the current models improvement program, the management structure, models and model evolutions. The Army model hierarchy is also discussed in relation to an analytical hierarchy.

#### Background and Management Structure

The idea of linking detail models of combat with highly aggregated ones dates back at least to 1971. At that time, the Army Models Review Committee discussed the need for a hierarchical set which would use outputs from high resolution models as inputs to less detailed ones.<sup>1</sup> Likewise, downward links could be established by using aspects of scenarios developed at theater level for input to lower level models. The perceived value of such a lash up between macro and micro models led to current Army efforts to produce an improved set of interconnected models.

The Army Model Improvement Program (AMIP) was created in 1988 as a direct result of the 1979 Hardison Review of Army Analysis. This review recommended the development and implementation of a family of integrated models with a supporting data base.<sup>2</sup>

The program is administered by the Army Model Improvement Program Management Office (AMMO) and Fort Leavenworth. The models range from

the theater-level to the lowest-level of combat. Each one is to be configured in four separate versions to meet needs for: training; personnel/equipment allocations and employment; research; and, model interconnection. Features of these four versions are:

(1) The Training Versions

- a. Interactive
- b. Consistent between levels
- c. Easy to use
- d. Emphasis on the Operational Art at the Theater-level

(2) Simulation Versions

- a. Operate without gamer interaction
- b. Investigate alternative weapon systems at lower levels
- c. Examine strategy at higher levels
- d. Analyze organization structures
- e. Use probabilistic event outcomes
- f. Yield a range of answers with same input data

(3) Research Versions

- a. Assess value of new doctrine
- b. Assess potential of new systems
- c. Provide insights to combat processes
- d. Provide insights to rear area processes
- e. Provide insights to human factors

(4) Interconnect Versions (Ersatz Models)

- a. Provide upward and downward links
- b. Provide order of battle distributions
- c. Provide attrition and consumption rates
- d. Provide compatible data between models

These four versions will be developed for a theater-level force evaluation model (FORCEM), a Corps and Division evaluation model (CORDIVEM) and a Combined Arms and Support Task Force Model (CASTFOREM). Model features are shown by Table III. Note that FORCEM will be derived from the current Concepts Evaluation Model (CEM). The hierarchical structure is shown by Table IV. All activities have responsibilities for data base development to support the four versions of each model level.

Development is to proceed by accomplishing seven major tasks:

<u>Task Number</u>	<u>Action</u>
1	Concept Based Requirements
2	Model Function Design
3	Assessment of Existing Models
4	Model Design Specification
5	Software Development
6	Data Base management System
7	Testing and Implementation

Analysis of user requirements is an ongoing process which is presently in its third iteration. Thus, Task Number One is a continuously developing check-list for planned uses and model constraints:

TABLE III  
HIERARCHICAL MODEL FEATURES

<u>MODEL</u>	<u>FEATURES</u>
<u>FORCEM</u>	<p>Two-sided, Symmetric, Combined Arms Model</p> <p>Evolved From CEM V</p> <p>Fast Running</p> <p>Linked to Hi-Resolution Division Model for Attrition Results</p> <p>Modular Development</p> <p>Operational December 1984</p> <p>Design Objectives Underway</p> <ul style="list-style-type: none"> <li>- Functional Area Input</li> <li>- Studies Verification</li> </ul>
<u>CORDIVEM</u>	<p>Two-Sided, Symmetric, Combined Arms Model</p> <p>Advanced Graphics</p> <p>Replace CACDA JIFFY Wargame</p> <p>Gamer Input Decision Logic</p> <p>Operational September 1982 in Interactive Version</p> <p>Attrition Linkage Demonstrated</p> <p><u>CORDIVEM Simulation Version</u></p> <ul style="list-style-type: none"> <li>- Design Objectives Task Force</li> <li>- Technical Assessment</li> </ul>

TABLE III (Continued)

Model	Features
CASTFOREM	Two-Sided, Symmetric, combined Arms Model
	Variable Resolution
	Extensive Decision Logic
	Enhancements
	<ul style="list-style-type: none"> <li>- Nuclear</li> <li>- INTEL/EW</li> <li>- Optimization of Code</li> </ul>

TABLE IV  
AMIP HIERARCHICAL STRUCTURE

MODEL	LEVEL	ACTIVITY	RESPONSIBILITY
	Scenario	DOD/DA	Scenario Development
FORCEM	Force/Theater (Several Corps/ Divisions)	CAA	Force Level Models
CORDIVEM	Major Organization (Corps/Divisions) Brigades/Task Forces	CACDA	Major Organization Models
CASTFOREM	Small Units (Battalions/Co.) Task Forces/Systems	TRASANA	Small Unit Processes
	ITEM/SYSTEMS	AMSAA	Individual Item and Weapon System Performance

Once the models are installed and used, an iterative improvement process is envisioned based on user feedback. The management structure for task accomplishment is shown by Figure 6. The Army Models Committee (AMC) gives guidance and assistance to the AMMO as required. The AMC also conducts periodic review of AMIP status.<sup>3</sup> The AMC, chaired by the Deputy Under Secretary of the Army for Operations Research (DUSA(OR)),



is the highest Army level responsible for management and direction of Army Modeling effort.<sup>4</sup>

TRADOC serves as the executive agency with the Commander, Combined Arms Center being the executive agent. Resource Groups include CAA, CASAA, TRASANA and their associated data bases. The Data Base Management Group includes representatives from DARCOM, OTEA, CDEC and others associated with basic data.

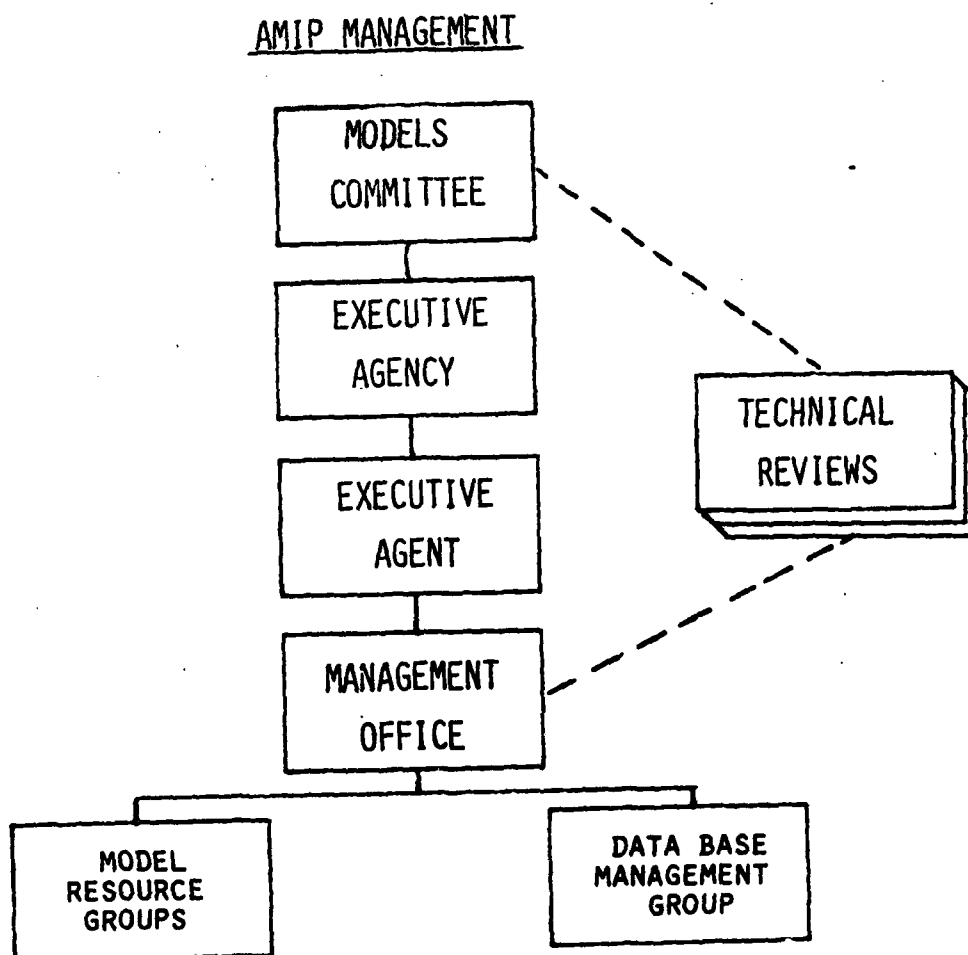


Figure 6 ARMY MODELS IMPROVEMENT PROGRAM MANAGEMENT

### Linkages Between Models

Model linkage will evolve with model development and be dependent upon directed study requirements. The use of compatible scenarios and common data bases will serve to increase the chance of similar outcomes from different models. The FORCEM/CORDIVEM interface can be enhanced by the use of similar offensive/defensive postures assumed for opposing forces. Similar terrain, visibility and mobility conditions used in both models will also add to their usefulness for compatible analysis.

Many other aspects of a theater-level study can be specified to be compatible with a study of one corps or division slice. Experience with the process will help refine the methodology and will further demonstrate the value of this type of analysis. In terms of results, a theater-level model played in highly aggregated terms can be much more believable when backed up by compatible results all the way down to high resolution battalion outcomes.

A suggested starting point for methodological development is to use CORDIVEM for a division analysis defending against three attacking Soviet divisions over high mobility terrain in clear, dry weather.<sup>5</sup>

A FORCEM Analysis of the Corps containing the CORDIVEM division could then serve to continue linkage methodology by conducting a study of CORDIVEM Corps and FORCEM Theater (Several Corps) results.

### The Evolution of Theater and Corps Models

FORCEM will address the issues of alternatives for improved force readiness, design of theater force structure, and determination of theater resources required for sustained combat operations. Its development is planned to take the shape of a series of discrete improvement steps from the current theater model, CEM-V. As CEM modules are rep-

laced or new modules are added, the model is planned to allow for structural changes while remaining available for concurrent studies. The effects of the modular changes can thus be examined in a stepwise fashion as the hierarchical program develops. Areas planned for improvement include  $C^2$ , intelligence, communications, maneuver/combat, electronic warfare, combat support, combat service support, air operations, and environment.

The Concept Evaluation Models (CEM) is a theater-level simulation of conventional war which evolved from Kriegspiel, the manual war game developed for the German General Staff in the 1930s. In CEM-V the battle area is divided into corps sectors with sub-sectors for brigades on the Blue side and divisions on the Red side. Attrition is calculated by the use of a force ratio index number that involves Weapons Evaluation Indices/Weighted Unit Values (WEI/WUV) scores. Terrain is treated in aggregated bands across sub-sectors. Supplies are explicitly treated. Penetrations can be treated to a limited degree with allocation of forces to flanks. The maximum number of types of units is 50. The force being simulated can contain up to eight different types of cannon. Direct support artillery is assigned to brigades/regiments. Time periods are: corps, one day; Army, two days; theater, four days. Shortage of supplies can affect outcomes. There are two notional aircraft types per side. There is an explicit command structure with decisions made according to decision rules based on force ratios and unit status. Three postures are available to units; attack, defend, delay. The many uses of CEM are shown by Table V.

TABLE V  
USES OF THE CONCEPTS EVALUATION MODEL

USE	PURPOSE	GIVENS	OUTPUT	IMPACT
JSCP (Joint Strategic Objectives Plan)	Influences Na- tional defense planning	1987 Threat National strategy	Force requirements Objective force	Shows minimum goals accept- able to JCS Shapes inter- service balance
TA (Total Army Study)	Supports Program Objectives Memorandum (POM)	1984 Other programs Threat Combat force Consolidated Guidance	Program force	Sizes Army
OM (Omnibus Study)	Capability review	1978 Other budgets Threat Real world force	Current force deficiencies	Quick fixes Adjustments in early pro- gram years
Amme Rats (Ammunition Requirements Study)	Determines ammunition reserves  Distributes ammunition assets	1984 Threat Combat force Weapon capabilities	Expected Ex- penditure of Ammunition (EEA), by type	Sizes Army reserves  Scales produc- tion base
WARF (Warfare Attri- tion Replace- ment Factors)	Determines equipment war reserves	1984 Threat Combat force Weapon capabilities	Expected equipment losses, by type	Sizes part Authorizes Acquisition Objective (AAO)
WARRAMP (Warfare re- quirement for Ammun- ition, Mater- iel and Personnel)	Both above, plus person- nel replace- ments	1984 Threat Combat force Weapon capabilities	Both above, plus per- sonnel losses	Both above, Personnel replacement policy
IDOFOR (Improved Def- inition of Objective Force)	Illuminates force design options	1980 Estimated resource constraints	Alternative 1990 force structure	Inferences of current threat

Source: U.S. Army Concepts Analysis Agency

The CORDIVEM Model is corps level in scope with the capability of simulating either a division or a corps. Its primary use is to supply information for design and force structure trade-off analysis of Army organizations such as brigades, divisions, and corps. A secondary use is to support studies of systems normally organic to major organizations. Its development has proceeded from the Integrated Corps (ICOR) Model and other models resident at CACDA.

The TOOR family of simulations (CLEW II, ICOR, TOOR, WARRANT) are for corps level operations and were designed to be applied to a variety of analysis including nuclear weapon use, interdiction, sensor systems, and command and control. The battle area is laid out on a hexagonal coordinate system allowing two-dimensional movement of forces. Penetration, encirclement, and over-run are explicitly represented. Attrition is calculated by a modified Lanchester equation including suppression, visibility, terrain, and other factors.

The model is operated interactively with the operator (force commander) on each side being presented with information from representations of sensor systems and from status reports on his own forces. The ground forces operate by the operations reaction system that responds to orders given, the status of the unit postured, and the situation. The time interval (usually five minutes simulated time) is the actual calculation time for events simulated. Weapon types are specific. Units move by operations codes and are affected by terrain, suppression, massing, and perceived threat. Artillery missions include target servicing indirect fire (TSIF), counterfire, interdiction, and suppression of enemy air defense. Air support is represented by a notional air base from which sorties are generated by the operator.

Aircraft types include helicopters. Air defense is explicit. Intelligence sensors are generic or specific depending on the version of the simulation. For explicit sensors (IMINT, SIGINT, and maneuver unit acquisition - air and ground) the information is processed and presented to the appropriate level of command. Logistic support is explicit for both conventional and nuclear operations. Command and control links exist from corps through battalion.

### AMIP/Analytical Hierarchies

Army Analysis is undertaken to determine the allocation of personnel, equipment and material to combat. Thus, studies determine how a force is to be structured, maintained, used and sustained. constraints of time and money further define the allocation process.

The numerous decisions involved are illustrated by Table VI, which shows the hierarchy of analysis to support the allocation process. The AMIP family of models is overlayed on this hierarchy to support force system analysis. The middle line in Table VI, denotes a crossover from highly quantifiable detailed studies to those involving increasing levels of intuition. Direct relationships between the analytical and AMIP hierarchies are also shown. For example, battle analysis to determine the best allocation of unit configuration of personnel and equipment, and their employment, can be supported by the FORCEM model.

In the 1980 GAO report on models, a caution is posed in proceeding from the "weapon configuration" type of analysis to the "weapon effectiveness" type of analysis because of differences between analytical levels.<sup>6</sup> Although the report did not discuss the formation of the AMIP, it did note that no single model or analysis is used to support allocation decisions. Rather, groups of studies tend to create consensus on major issues. Analysis interacts with intuition and opinions until major issues are resolved.<sup>7</sup>

The development of a consistent analytical process and exchange of information, considered important to the GAO report, will be enhanced by the AMIP evolution. This can occur by increasing model linkage and methodology in order to give greater depth to analytical studies.



TABLE VI

## ARMY MODEL IMPROVEMENT PROGRAM AND ANALYTICAL HIERARCHIES

<u>AMIP Model</u>	<u>Level of Analysis</u>	<u>Assessments of Effectiveness</u>	<u>Trade-offs</u>
FORCEM	Battle  Units Weather Topography	Casualties Movement Rates Weapons Attrition	Numbers and Types of Unit Unit Tactics
CORDIVEM	Encounter  Multiple Weapons Types Ceiling/Visibility Terrain	Targets Killed per Day/Sortie Exchange Ratios	Weapons Mixes Sub-unit Tactics
CASIFOREM	Engagement  Single Weapons Types Controlled Conditions	Probability of Killing a Single Target Probability of Loss to Single Attritor Type	Weapons Tactics and Design Features
<hr/>			
SYSTEMS LEVEL	Operations  Weapon Properties	Endurance Range/Speed Fire Rate	Design Specifications
TEM LEVEL	Engineering  Weapon Configuration	Weight Power Size	Design Features

Source: Extracted from Indices of Effectiveness in General Purpose Force Analysis, The BDM Corporation, 1974 and AMMO CSA briefing charts, Feb. 1982.

### TRADOC Models Management

In addition to the AMMO set of models there are many others that require management. Among these are combat developments and training models which are managed by TRADOC. A regulation is now being written to take an inventory of TRADOC models, other than those under AMIP, which require management attention.<sup>8</sup> A TRADOC Models Committee is to be formed by DCSCD in order to establish model goals, determine status of models and make recommendations for model development, enhancement and elimination.

The draft regulation envisions an annual TRADOC Model Program document which will include model reviews based on the work of a TRADOC models committee. As such, it will include an executive report, status of the model inventory, review and analysis of performance, and model plans and programs. It will also discuss advances in hardware, software and the modeling arts. Progress in data base management and necessary future directions will conclude the report.

The present draft regulation envisions a TRADOC Models Committee, established by DCSCD, HQ TRADOC, consisting of the following individuals:

- (1) ADCSCD - Joint Chairman
- (2) ADCST - Joint Chairman
- (3) Director, S&AD, DCSCD, TRADOC - Member
- (4) Director, Analysis Directorate, DCST, TRADOC - Member
- (5) Director, TRASANA - Member
- (6) Director, CASAA - Member
- (7) Director, BSDD, CATRADA - Member
- (8) Scientific Advisor, LOGC - Member
- (9) Scientific Advisor, SBC - Member

(10) Director, DSTD, ATSC - Member

(11) Technical Director, S&AD - Member and Recorder

The draft regulation, as now written, appears to be a significant step toward providing needed guidance to the modeling community. If fully implemented, the annual Model Program document can be a significant management tool. At the very least it could provide a convenient single source, catalog reference to TRADOC models. As for the regulation coverage, it appears that some "small" models may still escape inclusion, and thus management control.

The draft appendixes include a model survey form that can be computer coded, and a section for definition of terms. Both of these are in good draft form and can be easily improved and expanded as the TRADOC Models Management Program becomes reality.<sup>9</sup>

### CHAPTER III

#### ENDNOTES

1. 71 AMRC Report.
2. 78 Review of Army Analysis.
3. Proceedings, AMC Meeting, 6 November 1981.
4. AR on DUSA(OR) Charter.
5. Page 3 of Incl. 11 to AMC MTG 6 November 81, Proceedings.
6. GAO 1980 Report, Models, Data War, p. 45.
7. GAO 1980 Report, p. 47.
8. Draft TRADOC Reg 5-4, Management of TRADOC Models, DA, HQ, Army Training and Doctrine Command, Ft. Monroe VA.
9. Martin Shubik and Gary Brewer, Questionnaire: Models, Computer Machine Simulations, Games and Studies, pp. 1-71.

## CHAPTER IV

### SELECTED CONTRACTOR MODELING EFFORTS

Models, of course, are not a new concept, their development and use being integral to the physical sciences dating back conservatively, 500 years to Nicolaus Copernicus and, liberally, 2400 years to the Greek philosophers.<sup>1</sup>

Dr. Seth Bondar

Contractors play a significant role in military study and analysis.<sup>2</sup> Although not without criticism, their role in Army analysis is extremely important.<sup>3</sup> For example, Brewer and Shubik attribute the creation of the Studies, Analysis and Gaming Agency (OJCS/SAGA) to the work of RAND.<sup>4</sup>

The RAND Corporation is well known for their early work in the field of gaming and simulation. Their investment in modeling activity and analytical studies is considerable.

Prior to 1972, the Research Analysis Corporation was a major gaming and modeling center. At that time, however, it withdrew from its status as a Federal Contract Research Center (FCRC) and was assumed by General Research Corporation (GRC). Later still, GRC became a subsidiary of Flow General Corporation. GRC continues to do analysis for the Army but on a sharply reduced basis.<sup>5</sup>

One of the largest contract professional services firms is BDM International, Inc. (BDM)<sup>6</sup> For several years BDM has provided analysis for NATO/Warsaw Pact forces. They maintain active analysis in many

defense areas which include studies for weapon systems, intelligence, threat, air defense, ground combat and the impact of new technologies. In 1980, BDM expanded their capability to participate in advanced defense programs including cruise missiles, strategic mobility and light division vehicles.

Other modeling contractors, mentioned by Brewer and Shubik, include Stanford Research Institute, Battelle Memorial Institute, Tech Ops, Raytheon, General Electric, Booze-Allen Hamilton and Vector Research, Incorporated (VRI). Brewer and Shubik estimate that about 40% of DOD modeling activity is undertaken by the Army and that about 60 to 70% of this is done by contractors.<sup>7</sup>

#### Vector Research, Incorporated

Vector Research Incorporated, is an independently-owned company organized for the purpose of assisting government and industry in the structuring and solution of complex operating and planning problems. The company was formed in August 1969, to apply concepts in operations research and systems analysis to real-world problems.

The present full-time technical staff of VRI consists of engineers, scientists, mathematicians, and economists, a large majority of whom hold advanced degrees in their specialty fields. Present experience of staff members includes military services (several staff members are retired officers, and others have had extensive active duty experience), extensive academic experience (both teaching and research), industrial experience, and experience in both private and government organizations.<sup>8</sup>

VRI is well known for its pioneering work in modeling ground combat. From their work on modeling basic combat processes they produced

the Vector theater-level model. The latest of this series is VECTOR-3. VECTOR-2 is currently operational on the Command and Control Technical Center (CCTC) Honeywell System. Tables VII, VIII, IX and X show recent examples of VRI research for the Army.

TABLE VII

Conversion of VECTOR-2 to UNIVAC at TRASANA

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Contract: Contract Number 1859, US Army TRASANA, White Sands Missile Range New Mexico, 1981

Synopsis: Under the terms of this contract, VRI converted and implemented the AMDAHL version of the VECTOR-2 Combined Arms Combat Model on the UNIVAC 1100-82 at TRASANA. Supplementary documentation was developed and provided, and the model benchmarked a five day SCORES Europe I Sequence 2A Scenario. Sensitivity runs involving CAS, artillery effectiveness, and intelligence were executed and analyzed. In a parallel task, VRI examined the combat effectiveness analysis requirements of the I/EW MAA and Lethal Attack on Emitters Studies and identified VECTOR-2 modification necessary to support those studies.

Report: VECTOR-2 Documentation, VRI-TRADOC-7 FR81-1, 29 July 1981. Volume I: Main Report, Appendices A-D, Volume II: Appendix E, Sections E.1 and E.2, Volume III: Appendix E, Sections E.3 and E.4.

Letter to Mr. Gale R. Mathalsen, Director, USA TRASANA, VRI-TRADOC-7 FR81-2, 25 August 1981.

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TABLE VIII

Preparation of VECTOR-2 Corps Model to Play a Land/Air  
Military Campaign in the Mid-East

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Contract: C-274113, Vought Corporation, Dallas, Texas, 1981

Synopsis: The purpose of this effort was to develop a combat scenario placing a US Rapid Deployment Force in conflict in the Mid-East and to implement this scenario in the VECTOR-2 Corps level combat model. Representatives from the Army and the Air Force contributed to the development of the scenario, which represents a plausible contingency setting for the RDF. The project involved extensive modification to VRI's Corps level VECTOR-2 combat model; data collection on force composition, terrain, etc.; and formulation of tactical decision rules appropriate to the situation described. The scenario was implemented on the VECTOR-2 model, resulting in a base case which demonstrated areas for future study of contingency and mobile force operations.

Report: Southwest Asia Scenario SWASIA-1 (U), VRI-VOUGHT-5 FR81-1, VRI-G-81-18, Vector Research, Incorporated, Ann Arbor, Michigan, 3 April 1981 (SECRET).

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TABLE IX

Research for Fire Support Mission Area Analysis

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Contract: DAAG29-76-D-0100, Delivery Order Number 1519 from Battelle Columbus Laboratories, 1980

Synopsis: This contract for the specific scientific services of Dr. Robert Blum (USAWC-74) of VRI was administrated by Battelle for the Army. The objective of the required research was the identification and description of target array elements and characteristics that should be evaluated in subsequent fire support analyses. Since successful engagement of the target array is the ultimate measure for accomplishing the fire support mission, each analysis had, or was based on, a clear and comprehensive representation of the target array.

Report: Letter report, TRADOC-2 FR80-1, Vector Research, Incorporated, Ann Arbor, Michigan, October 1980.

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TABLE X

Analysis of Relative Values of Land Weapon Systems

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Contract: MDA903-78-C-0453, Assistant Secretary of Defense (PA&E), 1978

Synopsis: OSD(PA&E) typically uses static indicators to investigate questions relating to force structure and the balance of forces in various theaters. The primary indicators involve weighted linear sums of force weapons. The purpose of this study was to: examine relative marginal contributions of various ground weapon systems to force effectiveness as measured by exchange ratios and other attrition-based measures; examine the sensitivity of these marginal contributions to changes in data sources, assumed threat, and assumed force structure; and recommend a set of weapons class effectiveness indicators.

Report: Analyses of the Relative contributions of Land Weapon Systems to Force Performance, VRI-PA&E-1 FR79-1, Vector Research, Incorporated, July 1979, SECRET.

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#### MITRE Corporation

In FY 81, MITRE conducted research in the area of Army capabilities for C<sup>2</sup> evaluation and support of the command, control and intelligence directorate of the U.S. Army Combined Arms Combat Development Activity (CACDA). During this effort MITRE evaluated a total of some 100 studies regarding Army command and control. In addition, another 100 studies were screened for potential utility of information to the Army's overall C<sup>2</sup> evaluation effort. MITRE has developed research regarding a methodology to evaluate Army command, control and communications, which has been briefed within the analytical community and received favorable reception.

In FY 80, MITRE conducted a C<sup>3</sup> countermeasure analysis for the Electronics and Research Development Command (ERADCOM) and the U.S. Army Material and Readiness Command (DARCOM). Portions of the analysis were provided to TRADOC, and were incorporated in the U.S. Army TRADOC C<sup>2</sup> countermeasure concept of January 1981. MITRE is continuing its research regarding C<sup>3</sup> countermeasures in support of the TRADOC community and CACDA.

MITRE has considerable experience in the analysis of Army Weapons Systems and Tactical Doctrine, and in Command, Control, Communications and Intelligence (C<sup>3</sup>I) systems engineering. Staff personnel have expertise in Army and Air Force weapons system technology and engineering that make it possible to draw together technical teams capable of completing analysis of Army C<sup>3</sup>-CM capabilities. MITRE is a Federal Contract Research Center (FCRC) specialized in C<sup>3</sup> systems design and is qualified to provide systems research and planning technical support to the U.S. Army Model Improvement Program Management Office.

### ORI Corporation

ORI, Inc. was one of the first companies to provide analyses and evaluations of high technology systems in military applications. ORI began as Operations Research, Inc. in 1953 and was originally an independent, privately owned company. In 1968, ORI stock was sold to Reliance Group, Inc. (formerly Leasco Corp.).

ORI is now an employee owned company structured under the Employee Stock Ownership Plan (ESOP) legislation as incorporated in the Employee Retirement Income Security Act of 1974.

ORI's principal line of business is the performance of analyses for complex, high technology systems for the Department of Defense, the National Aeronautic and Space Administration (NASA), and the Intelligence Community. Analyses include review of state-of-the-art technology, assessment of the risks associated with the technological applications, evaluation of mission effects and the relative balance of power.

In addition, ORI provides system level support for technical management and engineering monitoring of the acquisition process for many major programs under the cognizance of the Environmental Protection Agency, the Department of Defense, the Department of Transportation, and the National Oceanic and Atmospheric Agency. In this regard, ORI has been supporting several clients for extended periods of time. As examples, ORI has had continuous contractual coverage with the Strategic Systems Project Office (PM-1) for 21 years and with the Office of the Secretary of Defense for 17 years.

ORI is able to respond to many diverse areas of expertise because of their in-depth technical background. The technical staff is organized into four functional operating groups: defense systems engineering; defense technology, research, and analysis; civil systems; and

space and communications.

Each group is headed by a vice president directly responsible to the office of the corporate president. Seventeen separate operating divisions have been established within these groups to address problem applications related to specific technical and subject matter areas such as: logistics and systems readiness and systems development; ship systems and systems engineering acquisition; information systems; transportation systems; energy and environment programs; space and communications systems; and space and data systems. These offices are supported by the Office of Computer Sciences. A close working management committee ensures that all specialized technical skills and expertise of the entire staff are made available to support programs or to supplement project team capabilities whenever required.

## CHAPTER IV

### ENDNOTES

1. Seth Bonder, "Systems Analysis: A Purely Intellectual Activity," Military Review, p. 15.
2. Gary D. Brewer and Martin Shubik, The War Game: A Critique of Military Problem Solving, p. 227.
3. Brewer and Shubik, pp. 227-235.
4. Brewer and Shubik, p. 59.
5. Brewer and Shubik, p. 68.
6. BDM International, Inc., 1980 Annual Report, p. 7.
7. Brewer and Shubik, p. 33.
8. Vector Research, Inc., Capabilities, p. 2-1.

## CHAPTER V

### THEATER LEVEL MODELS

Models have proliferated beyond the systems apparent willingness to catalog them in anything but partial listings of simple tabulations and brief descriptions.

Perhaps no one knows the exact number of Army models and how each one of them is used. If anyone does they have yet to produce a comprehensive document reflecting such knowledge.

Present catalogs are not as descriptive as they could be and the effort given to their production appears to be very low priority. As a result, the mystique of models continues, accompanied by the tyranny of unknown numbers.

General Reland. 1982

#### Catalog Listings

Selected Models from the Studies, Analysis, and Gaming Agency (SAGA), OJCS 1980 Catalog of War Gaming and Military Simulation Models, are shown in Table XI.<sup>1</sup>

TABLE XI

#### Theater Level Models in OJCS/SAGA Catalog

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##### US Army Concepts Analysis Agency (CAA)

TRM - Theater Rates Model

##### US Army Combined Arms Combat Developments Activity/Combat Operations Analysis Directorate

CACDA JIFFY War Game

TABLE XI (Continued)

Defense Communications Agency, Command and Control Technical Center

QUICK - Quick-Reacting General War Gaming Simulation

SNAP - Strategic Nuclear Attack Planning System

Academy for Interscience Methodology

SIRNEM - Strategic International Relations Nuclear Exchange Model

General Research Corporation/US Army Concepts Analysis Agency

ATLAS - A tactical, logistical and air simulation

ETNAM - European Theater Network Analysis Model

DBM - Division Battle Model

FASTALS - Force Analysis of Theater Administration and Logistics Support

CEM - Concepts Evaluation Model

SHAPE Technical Center

ATGM - Air and Ground Theater Model

Vector Research Inc./Defense Communications Agency, Command and Control Technical Center

VECTOR-2 - A Theater Battle Model

BDM Corporation/Defense Nuclear Agency (DNA)

COMBAT II - A differential equations theater model with nuclear orientation

BDM Corporation/US Army Air Defense School

DADENS-C2 - Divisional Air Defense Engagement Simulation Command and Control

US Army Materiel Systems Analysis Activity

DIVLEV - Division Level War Game Model

BDM-VRI/CACDA

DIVOPS - Division Operations Model

Computer Science Corporation/CACDA



TABLE XI (Continued)

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DIVWAG - Division War Game Model

OJCS-SAGA/Institute for Defense Analysis (IDA)-Command and Control  
Technical Center (OCTC)

IDAGAM II - IDA Ground Air Model II

Office of the Secretary of Defense (OSD)/IDA

IDAHEX -

IDA/OJCS-SAGA

TAOWAR - Tactical Warfare Model

DCSOPS/CAA

WARRAMP-WCEM

---

The catalog models shown by Table XI are listed under headings for the developer/proponent. The current catalog contains 175 one-to-two page model descriptions. The catalog also provides a list of models by proponent and developer. It does not include listings by generic purpose or unit level of combat.

The 1982 Catalog, currently being produced, does include an index to model type and breaks out theater-level models according to their primary orientation. It is presently being compiled and will add descriptions of the following models:

- (1) MTM - McClintic Theater Model (Developer/Proponent: US Army War College)
- (2) JANUS - Division and Battalion level (Lawrence Linermore National Laboratory (LLNL)/US Army TRADOC Systems Analysis Activity (TRASANA))
- (3) INWARS - Integrated Nuclear and Conventional Theater Warfare simulation (BDM Corporation/Deputy Under Secretary of the Army for

Operations Research (DUSA(OR))

(4) IDAGAM IIA - IDA Ground Air Model, version IIA (OJCS/SAGA and DCA/CCTC developers/OJCS/SAGA proponent)

(5) IOOR - Integrated Corps Model (BDM/DNA)

(6) CORDIVEM - Corps/Division Evaluation Model (Developer/Proponent: Combined Arms Studies and Analysis Activity (CASAA), Ft. Leavenworth)

Selected models from a 1980 publication of the Army Concepts Analysis Agency tabulation of 180 models are shown in Table XII.<sup>2</sup>

TABLE XII

CAA Catalog Models

Acronym	Name	Origin & Date	Remarks
TRM	Theater Rates Model	USACDC, 1967	A low resolution simulation for loss and measures of expenditure.
*ATLAS	A Tactical, Logistical and Air Simulation	RAC for ODCSOPS, 1969-70	Theater-level simulation
*ATWAR (listed in 79 catalog dropped in 1980)	Assessment of Theater Warfare	CAA, 1974	Standby model-uses COMFACA for air portion
*CEM V	Concepts Evaluation Model	GRC, CEM for ACSFO, 1971	Theater-level simulation
CLEW	Corps level Electronic Warfare Model	Braddock, Durn & McDonald, 1977	War Game includes Simulation of C <sup>3</sup> I. Used to analyze intelligence and EW systems
DEM	Division level Model	GRC from RAC	Dates back to RAC THEATERSPIEL

\*CAA has primacy

TABLE XII (Continued)

Acronym	Name	Origin & Date	Remarks
COMBAT II (in 1979 Catalog dropped in 1980)	Combat	Braddock, Dunn & McDonald, 1974	Theater-level simulation
DIVLEV	Division Level Game	AMSAA, 1974	War Gme
DIVWAG	Division Level War Game	USACDC DIVTAG Model, 1967	War Game at CACDA
*FASTALS	Force Analysis Simulation of Theater Admini- strative and Logistical Support	RAC for ODCSOPS, 1969-70	Linkage with ATLAS, CEM and FOREWON, a force and weapons analysis model.
FOURCE (Four C)	C <sup>4</sup> E	TRASANA, 78	Division Level
IDAGAM-II	Institute for Defense Analysis Ground/Air Model	IDA/WSEG, 1977	Theater-level simulation
IN ARS	Integrated Nuc- lear & Conven- tional Theater Warfare Simulation	Braddock, Dunn & McDonald, 77-79	Under development by BDM
JIFFY	Jiffy	ICAS, 1971	Manual War Game at CACDA
LULEJIAN-V	Lulejian- Vought	Vought Aircraft for Aeospace Defense Command, 1976	Theater level simulation
VGATES II	Force Evaluation		A gross model calibrated to results of ATLAS
TACWAR	Tactical Warfare Model (formerly IDA TACNUC)	IDA for OCTC 1975-77	Theater level simulation
*TARTARUS IV	Tartarus IV	CAA (STAG) 1965	Theater level War Game

TABLE XII (Continued)

Acronym	Name	Origin & Date	Remarks
T-CO (listed in 79 dropped in 1988)	Theater Combat Operations Model	Buddock, Dunn & McDonald (BDM) 1976-78	Theater level simulation
TFECS-CEM	Theater Force Evaluation by Combat Simulation Concepts Evalu- ation Model	Vector Research, Inc. (CAA contract)	Modified CEM
VECTOR-2	Vector-2	Vector Research, Inc., 1978 from Vector-1, 1973	Deterministic theater combat model
*WARP	Wartime Replace- ment Factor System	CAA, 73-75	Attrition Linkage Model
*WARRAMP	Wartime Require- ments for Ammu- nition, Materiel and Personnel	CAA, 78	Linkage Model

A OCTC catalog, published in 1977 also describes several of the models listed in CAA and OJCS/SAGA catalogs.<sup>3</sup> It was compiled by the Executive Support Office with Technical assistance from NAD (NMCS ADP Directorate) and replaced a 1975 catalog of NMCSSC Models. All models described are available on NAD Computers.

#### Concepts Evaluation Model

As of 1988, the Concepts Evaluation Model (CEM) was configured as CEM V.<sup>4</sup> However, in the 1988 Office of the Joint Chiefs of Staff/Studies, Analysis and Gaming Agency (OJCS/SAGA) Catalog it was listed simply as CEM.<sup>5</sup> It is described as being developed by General Research Corporation (GRC) for use by the U.S. Army Concepts Analysis Agency (CAA) to portray theater level, non-nuclear war in terms of battle lines, enemy forces and use of resources. Its primary purpose is for

force structure evaluation. Its estimated frequency of use at that time was 25 times per year with two months being required for data acquisition, 18 man-months for input to the model and two months for output analysis.

Development of CEM started in 1968 at Research Analysis Corporation (RAC). After some name changes it became CEM IV in 1974. It has been used by CAA to support Conceptual Design for the Army in the Field (CONAF) studies, Total Army Analysis (TAA) annual studies, support force structure requirements studies, OMNIBUS annual force assessments and materiel requirement studies.<sup>6</sup> Further model enhancements required for defense concepts resulted in CEM V being developed and used since 1979.

The most recent description of CEM V is also accompanied by a description of CEM/TFECS (Concepts Evaluation Model/Theater Forces Evaluation by Combat Simulation).<sup>7</sup> While time requirements for data base acquisition and structure have not changed significantly since 1980, the frequency of use has changed. CEM V is now being used over 30 times per year. The TFECS methodology is in the developmental stage and represents a modification of CEM for examining the effects of communications, intelligence and electronic warfare impacts on command decision processes. A typical application requires 25,000 inputs and about six technical man-months.

#### Force Evaluation Model

Closely associated with CEM is FORCEM, a model to be developed by CAA as part of the AMIP. Although CEM V has proven to be a useful model it has fallen short of meeting some analytical demands.<sup>8</sup> Capability improvements are needed in rear area processes and simulation of human decisionmaking behavior.

FORCEM is planned to be a discrete evolutionary improvement over CEM V by replacement of various CEM modules. It is expected to be more sensitive to combat support functions and to use data from lower level high resolution models. The end result will be a significantly improved capability to provide force planning study analyses.

Linkage will be made between FORCEM and CODIVEM (being developed by CASAA). CODIVEM is presently designed to study Corps and Division issues in three different versions: an interactive war game, a simulation and a training game. The basic difference between the interactive and the simulation version is the degree of simulated  $C^2$  functions. It is currently operational in the interactive version with impressive color graphics.<sup>9</sup>

#### Vector Research Corporation Models

The latest VRI combat model is VECTOR-3. Its lineage can be traced to the late sixties with the development of the BOMBER/IUA Model. About a dozen spin-off models resulted from this such as AMSWAG, FISTM, AIRCAV and TRACOM. In late 1973, VECTOR-0 was born to analyze issues from the battalion level on up. As decisionmakers expressed their opinions and intuition about combat processes, VECTOR-1 was developed by the end of 1974. Spin-offs from that effort included DIVOPS and NUC.

The concept of VECTOR model development is to put in only items which can be measured and to allow for discrete improvement steps based on new ideas. In this regard, VECTOR-2 represented a major improvement on VECTOR-1. It included more aspects of  $C^3$ I and explicit rear area processes for better representation of the battlefield. Timing intervals were also improved through the use of eight different clocks for time/event orientation. The basic VRI concept of model development is

shown by Figure 7. Note that it is iterative in nature with cycling and feedback occurring between concept and requirement from study to study.

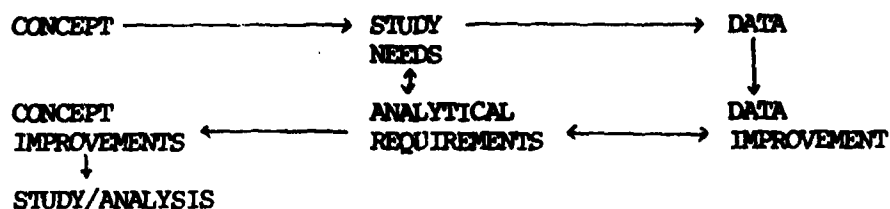


FIGURE 7. VRI Model Development Concept

Source: Interview with Dr. Seth Bonder, President, VRI at Spring 1982 ORSA/TIMS Conference.

Models are developed through their use in study and analysis. Thus VECTOR-2 led to the present development phase of VECTOR-3 which is now being massaged to meet future analytical demands.

A recent use of VECTOR-2 was for the SHAPE ARMOR/ANTI-ARMOR STUDY conducted in 1981.<sup>10</sup> The model was selected because of its ability to produce timely results using several variations of eight Corps. It was considered to be at the "state-of-the-art" in its form at the time of this study which was its first major use for simulation of airland combat.

As happens with most studies, the model was modified, enhanced and tailored to specific requirements. The scope of its application for the study was reduced from theater to corps level. Further refinement and calibration produced a flexible model. Study results were favorably received by both the analytical staff at the SHAPE Technical Center (STC) and the field units involved.<sup>11</sup>

A detailed review and critique of VECTOR-2 is contained in a 1977

report by Alan Karr.<sup>12</sup> Karr judged VECTOR-2 to be unquestionably superior to CEM, IDAGAM-I and Lulejian-I models.<sup>13</sup> Karr has also published reviews of each of these models in separate reports which are listed in the bibliography to this study. He gives good marks to VECTOR-2 because of level of detail, explicit coordinate geography, attrition methodology and representation of time, space and movement.

#### Catalog Descriptions

Descriptions of IDAGAM IIA, ATLAS, INWARS, TRM and MTM are provided in Tables XIII, XIV, XV, and XVI. These tables were compiled using extracts from the forthcoming OJCS/SAGA catalog.



TABLE XIII

IDAGAM IIA - IDA Ground Air Model, version IIA

**PROPOSER:** Organization of the Joint Chiefs of Staff, Studies, Analysis, and Gaming Agency (OJCS/SAGA)

**DEVELOPER:** Jointly by OJCS/SAGA and the Command and Control Technical Center (DCA/CCTC). Initial version of the model was developed by the Institute for Defense Analyses (IDA).

**PURPOSE:** IDAGAM IIA is an interactive model designed for computer-assisted manual force capability assessments of ground and air conventional combat.

**GENERAL DESCRIPTION:** IDAGAM IIA is a deterministic, interactive model of ground and air conventional combat between two opposing sides. The model is parameterized to allow building/sizing the model for a specific study (and its objectives) and for a specific region (and its level of detail).

The geographical structure of the model consists of a series of nonintersecting sectors, each sector consisting of intervals, each of which have a type terrain and combat posture assigned to them by the user. A region consists of one or more sectors, and is split into two depths behind the sectors. A communications zone for each side is located to the rear of the regions.

IDAGAM IIA has a fixed time step of one day. At the end of each day the user provides decisions and directions for the next day. These directions may include adjustments to the model geographical structure (distances, terrain, combat posture for any sector), engage/disengage forces, aircraft mission/sortie allocation and loadings, force movement, movement of supplies, etc.

The key compile-time parameters currently in IDAGAM IIA are:

- o Up to 75 sectors and 15 regions can be defined, subject to computer memory constraints.
- o Within each sector, up to 50 intervals may be specified.
- o Each interval is described by one of three types of terrain (slow, medium, or fast movement) and one of five combat postures (meeting engagement, prepared defense, breakthrough, constricted terrain, and urban warfare) for Blue/Red on attack matched with Red/Blue on defense.
- o Up to 200 ground combat units can be played per side. Each unit has three types of personnel (combat, combat support and combat service support) and 12 types of weapon systems, including AAA and SAMs. Quantities are recorded each day.
- o Up to 22 aircraft types per side can be played. Airbases played are notional, with each side having a forward and rear airbase

TABLE XIII (Continued)

in each region and one in the COMMZ. Eleven types of air missions are defined in the model.

- o Up to 26 types of supplies can be tracked by the model. The movement through the theater and consumption of these supplies are recorded. These supplies include up to 13 ground munitions and 10 air munitions. A switchable option in the model allows supply shortfalls to affect battle results.

IDAGAM IIA does not use firepower scores - an antipotential potential method is used to calculate the value of opposing weapon systems. Attrition by weapon type is calculated using the opposing weapons densities, capabilities, and allocation of fire.

**INPUT:** The model needs some 600 input variables and arrays. All input data are uniquely identified for input into a base case set of data files. Preprocessor programs operating in time-share mode are used for data entry and for format and variable verification.

**OUTPUT:** All output is in the form of computer printouts of user selected summaries or data records formatted as input to postprocessor programs.

- o Detailed Report (Used for debugging)
- o Daily Selected Summary Tables
- o Selected Summary Report
- o Time = t record of input decision implementation and of model operation.
- o Postprocessor programs operating in batch mode are used for specialized reports and data reduction.

**MODEL LIMITATIONS:**

- o IDAGAM IIA may not be operated as a computer simulation model.
- o Logistic aspects of the model are very aggregated.
- o Model is expected value vice Monte Carlo.
- o Conventional warfare only

**HARDWARE:**

- o Computer: HIS 6000
- o Minimum Storage Required: Depends on array limits desired - 162K words required in nominal case

**SOFTWARE:** Programming Language: FORTRAN V

**SECURITY CLASSIFICATION:** UNCLASSIFIED

**FREQUENCY OF USE:** 400-500 times per year

**USER:** Organization of the Joint Chiefs of Staff; Studies, Analysis, and Gaming Agency

TABLE XIV

ATLAS - A Tactical, Logistical and Air Simulation

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**PROPONENT:** US Army Concepts Analysis Agency

**DEVELOPER:** General Research Corporation

**PURPOSE:** ATLAS is a computerized, analytical model designed to assist the planner/analyst by simulating conventional theater-level combat operations over an extended period, and to examine the overall trends, effects, and interactions of ground, air and logistic forces in conventional theater-level warfare. It is basically a planner's war game, providing the tool for examining theater-level force interactions so that the planner/analyst may examine and evaluate theater contingency planning, force effectiveness and force requirements. The daily movement of a FEBA is developed as a function of firepower, terrain, posture, residual personnel strengths, and logistic support. The model is also concerned with the scheduling of reinforcements and logistic capability of lines of communication.

**GENERAL DESCRIPTION:** ATLAS is a two-sided, deterministic model involving land and air forces. It was primarily designed to consider division level ground forces and aircraft by mission. The model may be manipulated, however, to consider units down to brigade or battalion level, if the gamer can accept division casualty and movement "rates." The model was designed to consider combat operations by "sector." Each "sector" was designed to represent a corps level force. Up to ten sectors (corps) can be simulated in a representation of theater level combat. Time is treated on a time step basis (24-hour increments). The primary solution technique is average expected value results evaluated deterministically.

**INPUT:**

- o In general, inputs fall into four major categories:
  - (1) Environmental inputs which structure the theater;
  - (2) Ground force inputs of committed and scheduled forces and their associated characteristics;
  - (3) Logistic inputs which establish supply requirements and constraints;
  - (4) Air inputs which provide performance, vulnerability, and other characteristic data on aircraft, airbases, and SAM sites.

**OUTPUT:** Model output is in computer printout form similar to the input data format. Output is tabulated on a daily basis and reflects

TABLE XIV (Continued)

the current status of forces at a given time. Selective detailed and summary output is available. Output may be requested for specific days and for specific submodels (ground, air or logistics) or for a comprehensive theater summary. Retrievals of selected data items are also available using the ATLAS data conversion and retrieval programs.

**MODEL LIMITATIONS:** In ATLAS, the battle assessments are primarily dependent on the ratios of the opposing forces computed from firepower scores (FPS). The Index of Combat Effectiveness (ICE) values are modified by casualties or lack of supplies to form a net ICE. At the present state of gaming, weapon firepower effects are assumed to linearly additive with no enhancement (or degradation) for training, morale, combined arms, and command and control.

**HARDWARE:**

- o Computer: UNIVAC 1100 series
- o Operating System: UNIVAC 1100 Operating System
- o Minimum Storage Required: 53K words
- o Peripheral Equipment: Mass storage devices

**SOFTWARE:**

- o Programming Language: ASCII FORTRAN
- o Documentation (DTIC Numbers):
- o - "Computerized Quickgame" RAC-TP-266 (AD 387 510), ATLAS:  
A Tactical, Logistical and Air Simulation: RAC-TP 338  
(AD 850 355)
- SHAPE TM 242
- NMCC CSM \*M 91-69
- Modifications to ATLAS (ATLAS-M), CAA-TP-74-3, July 1974

**TIME REQUIREMENTS:**

- o 2-4 months to acquire base data, depending on Service responses
- o 1 man-month to structure data in model input format
- o 20 minutes computer time for 180 day game on UNIVAC 1100/82

**SECURITY CLASSIFICATION:** UNCLASSIFIED

**FREQUENCY OF USE:** Support for 3 or 4 studies per year

**USERS:** US Army Concepts Analysis Agency and COMUSKOREA

**POINT OF CONTACT:** UNIVAC version - Ms. P. M. Fleming  
US Army Concepts Analysis Agency  
(CSCA-MOM)  
8120 Woodmont Avenue, Bethesda,  
MD 20814  
Telephone: (202) 295-0529

TABLE XV

INWARS - Integrated Nuclear and Conventional Theater Warfare Simulation

---

PROPOSER: Deputy Under Secretary of the Army for Operations Research

DEVELOPER: The BDM Corporation

PURPOSE: INWARS is a computerized fully automated simulation for analysis of a general war situation. It was developed to allow examination of doctrine and issues in decisionmaking in a theater nuclear, chemical, and conventional context. Of particular interest are the reactions of C2 elements to perceived enemy preparations, defensive measures, and other actions influencing nuclear warfare decisions. Emphasis is on decisionmaking processes of ground C21 elements at echelons above division.

GENERAL DESCRIPTION: INWARS is a two-sided deterministic unit-centered model of the land theater battle. It represents units down to brigade and regimental level with spatial resolution of 9.5 km. Combat and CSS units, airfields, air missions, and special weapons packages are fundamental entities. Direct and indirect fire combat, air warfare, air defense, and the use of nuclear and chemical weapons are represented. Repair, supply, and intelligence collection are also included.

The emphasis in the model is on decisionmaking with each headquarters at corps level and above represented by an entity which makes decisions and plans. This is accomplished using a knowledge based technique known as "frames," which provide a context for maintaining an "Understanding of the Situation (UOS)." These headquarters units make plans for ground operations, (e.g., envelopments), develop targeting plans, monitor the performance of subordinates, and react to contingencies.

The simulator consists of the two primary modules, one for the combat interactions, which is a time stepped unit capable of running stand alone with initial unit orders, and the C3I module which is event stepped. Interfaces between the two are implemented as messages.

TABLE XV (Continued)

INPUT:

- o Order of Battle
- o Weapon/Asset description parameters, including weapon effects
- o Terrain data
- o Operation decision tables (division, brigade, air, etc.)
- o SOPs
- o Operation descriptors, defining various operation type
- o Operation concepts (for corps and above)
- o Decision criteria
- o Information collection parameters
- o Understanding of the situation-fundamental knowledge

OUTPUT: Summary of situation at predetermined times, including unit locations, state information. Summary of individual understanding of the situation.

MODEL LIMITATIONS: Currently designed to handle a situation of approximately:

- o 100 km x 1000 km area
- o 50 Corps and above headquarters
- o 2000 units, with about 6 assets each

The above limits can be expanded with major modification.

HARDWARE:

- o UNIVAC 1108 200K words
- o CONTROL DATA CYBER 176 200K (octal) words, SCM, 40K (decimal) words ECS

SOFTWARE:

- o Programming Language: FORTRAN with MIDAL data structure preprocessor
- o Documentation: Integrated Nuclear and Conventional Theater Warfare Simulation (INWARS) Documentation, (3 parts, 12 volumes). The EDM Corporation, Feb 8, 1980
- o Size: Combat Interactions Module 10K lines source  
C3I module 30K lines source  
Data inputs, typical 3K lines

TIME REQUIREMENTS:

- o To acquire data base: 7 man-months
- o To structure data in model input format: 3 man-months
- o To analyze output: 2 man-months
- o Analyst learning time: 6 months
- o CPU time per replication: 8-1 simulated/real time

TABLE XV (Continued)

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FREQUENCY OF USE: Not yet used in study.

USERS: US Army Concepts Analysis Agency  
The BDM Corporation

POINT OF CONTACT: Mr. Louis W. Schlipper  
Director, C3I Systems Analysis  
The BDM Corporation  
7915 Jones Branch Drive  
McLean, VA 22102

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TABLE XVI

TRM - Theater Rates Model

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**PROponent:** US Army Concepts Analysis Agency

**Developer:** US Army Concepts Analysis Agency

**Purpose:** The Theater Rates Model is a computerized model used for analysis. It simulates theater level combat over a predetermined span of time.

**General Description:** The Theater Rates Model is a two-sided deterministic model. It simulates theater level conflict on a day-by-day basis in order to determine ammunition expenditures of all Army weapons engaged in conflict. Its primary solution technique is that of a computer simulation algorithm.

**INPUT:**

- o Personnel casualties and armor losses from all forms of combat
- o Red and Blue force deployment schedule
- o Scenario of combat activity

**OUTPUT:**

- o Computer printout of day-by-day ammunition expenditures
- o Status of both Red and Blue forces in the theater

**MODEL LIMITATIONS:**

- o Combat activity is dictated by a scenario
- o Blue and Red deployed units are aggregated

**HARDWARE:**

- o Computer: UNIVAC 1100 series
- o Operating System: UNIVAC 1100 operating system
- o Minimum Storage Required: 40K Words
- o Peripheral Equipment: Data entry device and printer



TABLE XVI (Continued)

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SOFTWARE:

- o Programming Language: FOTRAN
- o Documentation: Theater Rates Model, December 1974, USACAA.
- o Preceding publication represents complete user's and technical documentation

TIME REQUIREMENTS:

- o Approximately two months to acquire basic data
- o Two weeks to structure data in model input format
- o Five minutes CPU time per model execution on a UNIVAC 1100/82

SOFTWARE:

- o Programming Languages: UNIVAC FORTRAN V, and Assembly Language
- o Documentation: "TARTARUS IV N/COO Players and technical Manual." (AD 829 5251)
- o Technical documentation is complete; user's documentation is not. The model has been modified since the above documentation is not. The model has been modified since the above documentation was published and corrections have not been published.

TIME REQUIREMENTS:

- o Four months to acquire base data
- o Two man-months to structure data in model input format
- o Average of 1/2 hour CPU time per model cycle on a UNIVAC 1108 (Four hours real time)
- o One week learning time for users
- o Two months to analyze and evaluate results of one study

SECURITY CLASSIFICATION: UNCLASSIFIED

FREQUENCY OF USE: Five studies

USERS: US Army Concepts Analysis Agency

POINT OF CONTACT: Ms. P. M. Fleming  
US Army Concepts Analysis Agency (CSCA-MCM)  
8120 Woodmont Avenue  
Bethesda, MD 20814  
Telephone: (202) 295-0529

KEYWORD LISTING: Analytical Model; Limited War; Land Forces;  
Computerized; Two-Sided; Deterministic; Time-Step

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TABLE XVII

MTM - McClintic Theater Model

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**PROFONENT:** US Army War College

**DEVELOPER:** US Army War College

**PURPOSE:** The McClintic Theater Model was designed to fulfill two purposes at the US Army War College. It is used as part of the Army War College Curriculum as an educational tool for senior officers, and it is used by general officers and their senior staff as an analytical tool to examine corps strategy, tactics, and sustainability as part of the US Army Tactical Command Readiness Program. The model is used to compare alternate military concepts, strategies, and forces in order to gain insight into potential problem areas and to uncover opportunities for success. It serves as a dynamic discussion vehicle for examining time and space relationships on the battlefield, to include joint operations. Utilization of the model allows the players to become familiar with real-world aspects of the terrain and units in the order of battle.

**GENERAL DESCRIPTION:** The McClintic Theater Model is a closed, two-sided, four-service, interactive computer model that allows simultaneous input of orders from both sides. It is built on a philosophy which recognized that those who participate in the war game learn the most from it. Consequently, the model has been written so that the players do not need a knowledge of computer programming. Player inputs (orders) are entered in a natural, English-like manner in which spacing, order, and extraneous words do not matter. The model is time driven at rates varying from zero up to 72 to 1, dependent upon the players' ability to keep up. It is a four-service model that not only looks at each service separately, but also looks at the interactions between services, such as airlifts, sealifts, naval gunfire, suppression of enemy air defenses, close air support, and interdiction. Factors considered include weather, intelligence, local population, ten classes of supplies, unit-carrying capacities, and others.

**INPUT:**

- o Pregame
  - Terrain and road network data
  - Orders of battle (25 data items on each unit)
- o During game
  - Orders to units (free form, English-like)

OUTPUT:

- o During Game
  - Estimated times of arrival
  - Logistics warnings
  - Logistical reports
  - Situation reports
  - Intercepted enemy radio traffic

FREQUENCY OF USE: Monthly at USAWC

USERS: JCS/SAGA, Pentagon  
Readiness Command, MacDill AFB, FL  
VII Corps, Stuttgart, FRG  
Army War College, Carlisle Barracks, PA

POINT OF CONTACT: Commandant  
US Army War College  
ATTN: AWCAG (Mr. Fred McClintic)  
Carlisle Barracks, PA 17013  
Telephone: AUTOVON - 242-3017  
Commercial - (717) 245-3017

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## CHAPTER V

### ENDNOTES

1. Studies, Analysis and Gaming Agency (SAGA), Office of the Joint Chiefs of Staff (OJCS), Catalog of War Gaming and Military Simulation Models, 8th Ed., pp. 1-388.
2. U.S. Army Concepts Analysis Agency (CAA), Tabulation of Models of Interest to CAA, pp. 1-21.
3. Command and Control Technical Center (CCTC), A Catalog of NMCS ADP Directorate (NAD) Capabilities, pp. 1-64.
4. Philip E. Low and R. E. Johnson, Concepts Evaluation Model V, Jan 1980, pp. 1-1 to 8-3.
5. SAGA Catalog.
6. Low and Johnson, p. 1-1.
7. Studies, Analysis and Gaming Agency, Office of the Joint Chiefs of Staff, Catalog of War Gaming and Military Simulation Models, 9th Ed., (DRAFT).
8. Major General Edward B. Atkison, "Toward an Improved Theater Level Model," PHALANX, p. 5.
9. LTC Richard E. Garvey, Jr. and Timothy J. Barley, "The Corps/Division Evaluation Model," pp. 1-11 (paper presented at Detroit ORSA/TIMS Conference, 1982).
10. J. N. Banks, G. P. Hawkins and V. P. Wood, The Use of VECTOR-2 in the SHAPE Armor/Anti-Armor Study, pp. 1-31.
11. Banks, Hawkins and Wood, p. 24.
12. Alan F. Karr, Review and Critique of the VECTOR-2 Combat Model, pp. 1-78.
13. Karr, p. 31.

## CHAPTER VI

### THE McCLINTIC THEATER MODEL

#### Model Purpose, Use and Benefits

The McClintic Theater Model (MTM) was designed and built by Mr. Fred McClintic, Director of Systems Support, at the U.S. Army War College. General Meyer, CSA, is the originating authority. Its purpose is threefold, (1) Training and Education, (2) Force Structure Evaluation and, (3) Evaluation of Operational Plans. It has received wide attention and has been adopted by the following users:

- (1) Joint Chiefs of Staff
- (2) Chief of Staff of the Army
- (3) U.S. Army War College
- (4) National Defense University
- (5) Armed Forces Staff College
- (6) Command and General Staff College
- (7) U.S. Military Academy
- (8) Readiness Command
- (9) U.S. Forces Korea
- (10). V and VII Corps
- (11) Naval Post-graduate School

The MTM was first used in 1980 and has been used at an increasing rate since that time. Over 100 briefings have been given on the use of

MTM to audiences including most of the Armys Division Commanders. MTM has helped realign some missions through its use in a CSA Contingency Planning Exercise and has aided operational dialogue between Commander through such exercises as VII Corps Cold Reason.

MTM uses a flexible, top-down structured approach and can be readily adapted on any computer with a FORTRAN compiler. No modifications are required for its use on any of the 35 WWMCCS computers.

#### Model Characterization

A written scenario is needed for model use. It is characterized by a moderate level of detail and includes the following items:

1. Order of Battle  
25 data items per unit
2. Terrain, Roads, Bridges, Minefields
  - a. Trafficability within hexagons
  - b. Trafficability between hexagons
3. Times, Probabilities and Weather
  - a. Sunrise, sunset
  - b. Probabilities of detection
  - c. Probabilities of kill
  - d. Four different weather conditions

MTM operates with a player/controller variable speed rather than event oriented timing. A typical game will see the players using real time in the beginning and then going to a 12:1 ratio as their familiarity and ability increases. The level of resolution for model time is in seconds. The level of spatial resolution can vary dependent upon the selected map scale. In terms of resolution of detail for units it reports aggregated results down to small, structured combat units. Details of engagement are reported every two hours.

Random events are allowed for air-to-air and ground-to-air. The ground-to-ground and surface-to-surface processes are deterministic.

### Planning Factors and Documentation

There are about 200 input parameters that must be specified in order to use MTM. An average exercise will produce 200 pages of output. All data can be modified during the game. Initial input can be done in one day.

MTM is described in four volumes:

Volume I : War Game Directors Manual

Volume II : War Game Users Manual

Volume III: War Game Controllers Manual

Volume IV : War Game Programmers Manual

Volume IV will contain overall documentation which will enhance model transferability between different geographical locations. Volume I provides an overview of model design, philosophy, capabilities, and limitations. It explains program structure, modules and input requirements. Figure 8, shows the various functional systems. Each item shown is a separate program module which may be changed as the model matures.

Figure 8, also explains the top-down model structure which allows for separation of model design into a series of subroutines, which together make up the total simulation.

Volume II contains a set of user instructions with simple examples for each type of input. Volume III gives control statements for entering and changing basic data.

# THEATER COMMANDER'S INTERFACE WITH HIS FUNCTIONAL SYSTEMS

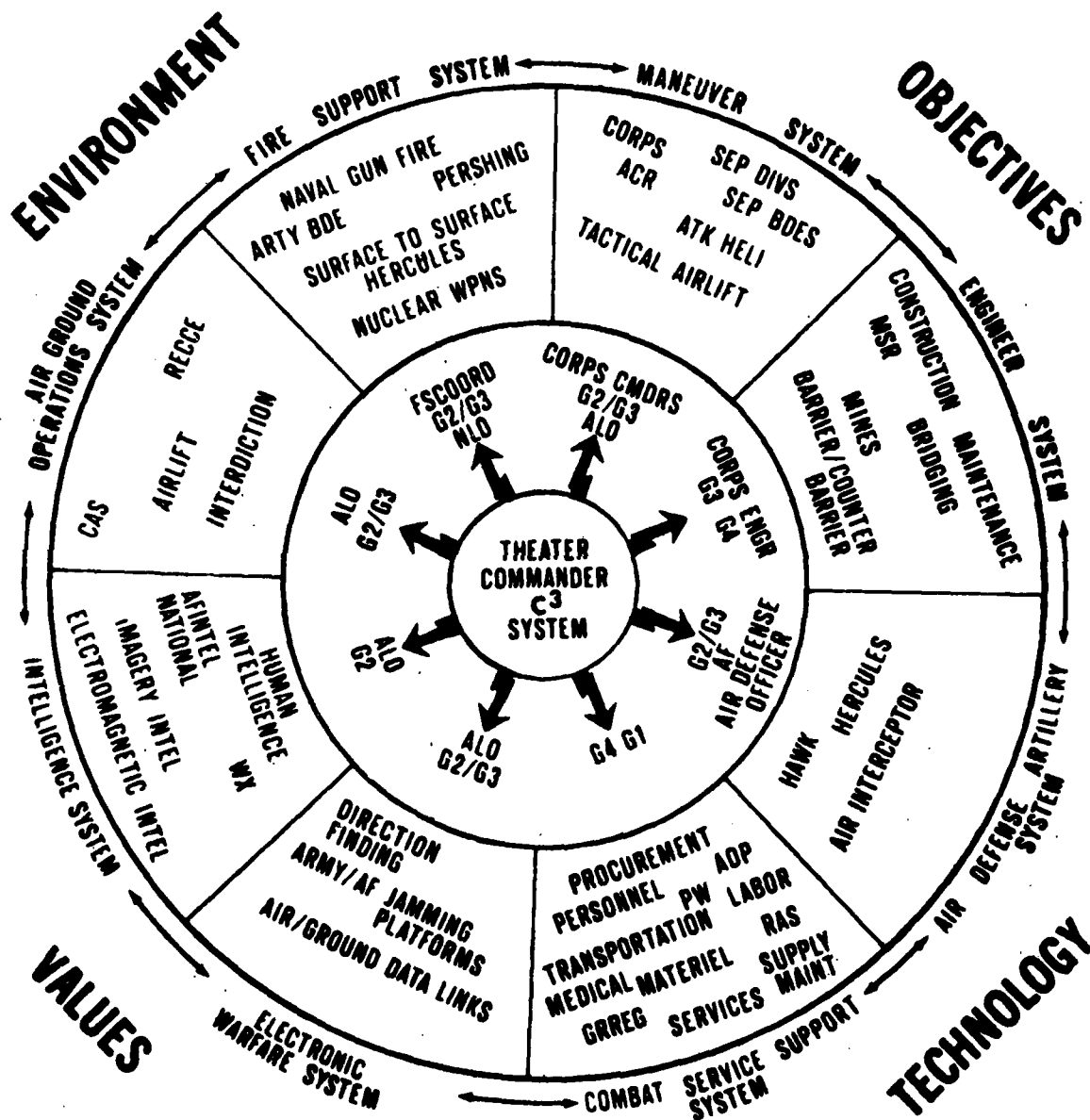


Figure 8 MC CLINTIC THEATER MODEL SYSTEMS



The MTM is a closed, two-sided, interactive computer model. It allows simultaneous input of orders from both sides. A knowledge of computer programming is not required in order to play a war game with the MTM. Input orders are entered without regard to spacing or order of words. Extraneous words are also allowed. The model is time driven at rates varying from 0 up to 72:1. Normal ranges are from 5:1 to 24:1. It is a four service model that can address such features as: airlifts, sealifts, naval gunfire, suppression of enemy air defenses, close air support, and interdiction. Factors considered include weather, time of day, trafficability of terrain and road networks, electronic warfare, intelligence, local population, ten classes of supplies and unit carrying capabilities.

Pregame inputs consist of terrain and road network data and order of battle (25 data items on each unit). Of particular significance is the brief one day period to input data for a change in scenario.

During the game, outputs are provided for estimated times of arrival, logistics warnings, logistical reports, situation reports, intercepted enemy radio traffic, indirect fire damage reports, airstrike damage reports, nuclear/chemical weapons usage, intelligence reports (five types) and, combat/battle reports.

After action analysis can be provided in the form of graphical outputs such as graphs, bar charts, map, or a printout of specified variables.

The model allows for up to 300 units. Maximum map dimensions for a hexagon overlay are 6 ft. by 8 ft. Both units and dimensions can be expanded if additional computer memory is available.

Hardware consists of a Honeywell 6060 (belonging to the World Wide Military Command and Control System (WWMCCS)) or Altos 8000 series

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THEATER LEVEL WAR GAMES. (U)  
JUN 82 G L PAULER

ARMY WAR COLL CARLISLE BARRACKS PA  
THEATER LEVEL WAR GAMES. (U)  
JUN 62 G L PAULER

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microcomputer (FOTRAN and PASCAL versions respectively). The minimum storage requirement is 69K for the Honeywell and 208K for the Altos.

#### The USAWC Student War Gaming Model

A "Pascal" version of MTM was first used by the USAWC Class of 82. Pascal is a computer program language especially suited to interactive terminals. The model was devised by Captain Aaron Coleman, Chief, Computer Simulations and Modeling Branch, with Brannon and Moss. Its purpose is specific to training in the operational art of warfare. The process of play and player interaction is considered more important than game results. Eighteen separate games were conducted with the entire class broken down into red and blue teams.

Model resolution is similar to the parent MTM. ALTOS 8800 series computers are used for conducting exercises. At this time there is a player and operations guide but no documentation for equipment set-up, program maintenance or enhancement.

#### External Evaluation

During the summer 1981, two USMA faculty serving with OJCS/SAGA conducted an evaluation of MTM.<sup>1,2</sup> They concluded that MTM has excellent potential for providing rapid, timely analysis to crisis-oriented planning and study issues of the Office of the Joint Chiefs of Staff (OJCS).

The potential of MTM for planning and study methodology is to be explored in connection with a finer grained model as shown by figure 9. MTM can serve as a rapid response tool for analysis and may be readily altered to conform to study requirements. Major elements requiring further refinement include logistics, close air support, communications

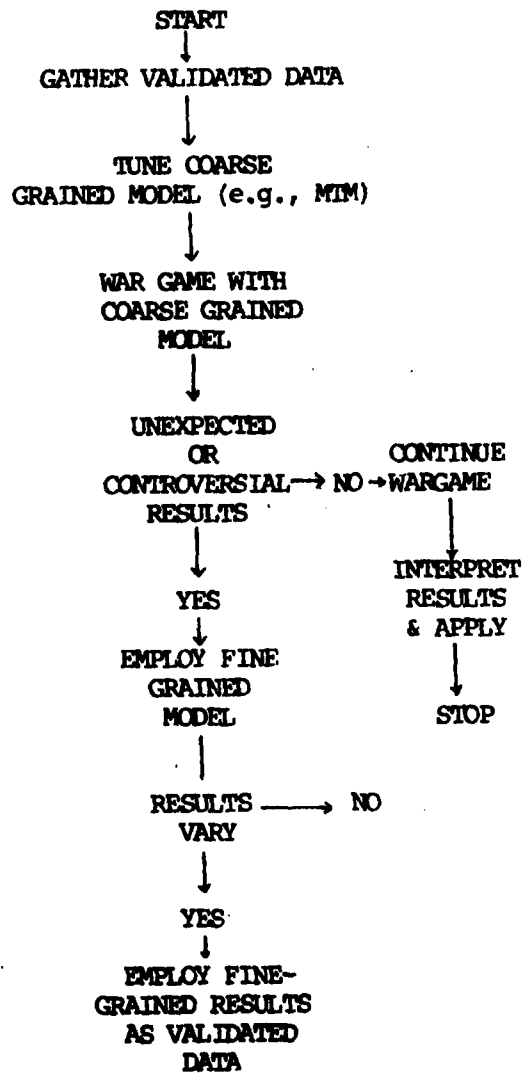


FIGURE 9. Potential Wargaming Methodology

and engagement attrition. As the model is adjusted and tuned to validated data it can be used in a stand alone capacity (for time critical studies) or used as part of more time consuming analysis with a more detailed model. To the extent that results are compatible, each model would tend to support the other.

In the overall evaluation, Dees noted that MTM has been undergoing a continuing process of refinement since its first use in 1980.<sup>3</sup> He also recommended several modifications to enhance model capability and realism. His detailed evaluation covers data input, terrain representation, units, timing, movement, attrition methods, artillery, engagements, air, logistics and computer graphics capabilities. His report is generally favorable and he notes model strengths as well as weaknesses. For example, he points out that MTM data preparation and input time requirements are measured in days whereas models such as ATLAS or CEM require weeks or months.

#### Proposed Model Enhancements

(1) For ground forces (blue), the Brigade would be the basic MTM unit manipulated by the player. The assessments (and SITREPS) would be accomplished by sub-element consideration. Suggest one "board" player and one "CRT" player to handle each division.

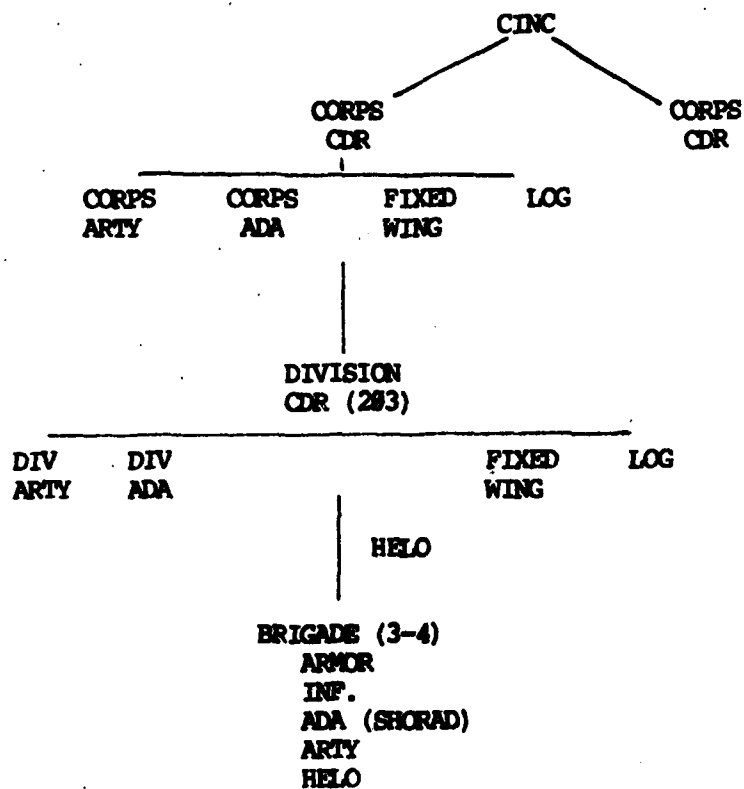
(2) For ground forces (red), the MRD would be the basic MTM unit. Other red units are similar to blue units.

(3) Each unit carries a mission designation with attrition coefficient (and movement) input for each mission.

(4) Ammo types (and system types) must be distinguished for ARTY, ADA, and air units.

(5) Explore possible sources of assessment methods.

Figure 10 shows a proposed organization for a Southwest Asia scenario.



**FIGURE 10. Proposed SWASTA Organization**

### Student Reactions

The US Army War College Class of 1982 was the first to use the student war game (Pascal version of MTM) during the spring of 1982. Each of 16 seminar groups were divided into Red and Blue sides to play concurrent, independent war games. The first set of war games used a NATO scenario. After these were finished, related instruction was presented prior to playing another set of war games using a SWASIA scenario.

Oral and written surveys were conducted throughout the war game instructional period. Student reaction was generally favorable. The war game controllers were volunteers who generally desired to learn more about war gaming.

The major complaint was the lack of logistic play, control features and the massive output of tactical game results. Players and Controllers generally learned more about NATO and SWASIA threats and some features of the operational art. Several individuals stressed the need for more instruction and the time to play more than one complete game per scenario. Others expressed an interest in setting up a competition between seminar groups rather than within them.

Almost all individuals surveyed thought that MTM had potentially outstanding training value but that more instruction and planning time would be helpful, especially regarding the use of operational art.



## CHAPTER VI

### ENDNOTES

1. f. John R. Edwards, USMA, memo to Scientific and Technical Advisor, OJCS/SAGA, 28 September 1981.
2. f. Robert F. Dees, A Detailed Analysis of the McClintic Theater Model, 28 September 1981, pp. A-1-I-2.
3. Robert F. Dees.

## CHAPTER VII

### THE CHALLENGE OF THE FUTURE

To deny reality is to affirm it, and to assert abstraction is to deny it . . .

Anonymous

#### Power and Threat

Throughout history, sovereign states have employed military power as one means of coercion. The mechanisms through which the military power of one state may affect the behavior of other states are three-fold. The first mechanism of power is witnessed during the actual fighting experienced in armed conflict. The second mechanism is the threat of military action and the third is through the anticipation by a state that another may proceed to use its military forces in the event of a serious conflict.<sup>1</sup>

Consideration of mechanisms two and three play the most critical role in evaluating costs and effectiveness of an armed conflict using the techniques of Operations Research in the design and implementation of war games. The list of factors which specify the conditions under which a state is willing to resort to a military threat will range from extremely high to zero. Actualized military power is thus dependent on a balance of weighing the costs of making threats and the values at stake.

Operations Research, during peacetime, has been directed toward

cost-effectiveness problems in a relatively stable environment under which costs can be delineated to a greater degree of predictability. In industry, cost-effectiveness problems are often separable; whereas, military cost-effectiveness studies, during wartime, must be expressed in terms of intangible variables ranging from human life factors to national objectives.<sup>2</sup>

Predicting future probability of a military threat can only be approximate. Since 1964, we have been warned about the perils involved in using the wrong or different criteria in cost studies. This warning came from Senator Pastore of Rhode Island who said,

Our potential enemies may not use the same cost-effectiveness criteria and thus oppose us with the best weapons their technology can provide. This would create an intolerable peril to the national security.<sup>3</sup>

The methods involved in Systems Analysis are basically intellectual. Their purpose is to increase knowledge by replicable means. They lend themselves to decision-making when evaluating choices between specified alternatives.

#### The Impact of Judgment

The tools of Operations Research/Systems Analysis are of no avail if a decision-maker is induced by circumstances beyond his control, to act irrationally, or at a low level of rationality. It is in this regard that Senator Pastore's statement gains its realistic impact in today's military environment. The choices made in response to decision-making are still subject to the skill of leadership. The propensity to accept military risks and to approach crisis situations rationally are important since government and military leaders differ in this respect.<sup>4</sup> Some leaders have a stronger propensity to act rationally than others,

and some are more inclined than others to run risks.

Because of the nature of man and modern thought, Operations Research and Systems Analysis has incorporated more useful techniques for evaluating unknown risks and alternatives. Techniques, such as simulation, modeling and war gaming have proved themselves to be invaluable aids to the art of managerial decision-making.

### Predictions

Futurists seem to agree that the world will change very rapidly during the next 20 years. Although the rate of change cannot be extrapolated to the future with any degree of certainty, logical predictions indicate that rapid changes will continue for the next few decades.

One of the most important predictions about the future is the continued growth and expansion of computers at all levels of use. Computer models are currently used extensively in the Operations Research and modeling communities. With the growing rise in technology, the hardware costs for using computer simulations in modeling and gaming are decreasing and will continue to decrease. Nevertheless, the challenge of the future lies in the formulating of perfect or more realistic models.<sup>5</sup> The usefulness of models is reduced unless it is determined how well they represent a selected portion of reality.

The type of model employed implies a particular paradigm of problem solving. Predicting the future and preparing for it are its two basic functions.

It becomes necessary to understand the conditions which allow perfect prediction.

Perfect prediction is possible under two conditions:

- (1) When nothing changes; or,

- (2) When the behavior that is being predicted occurs in accordance with continuity of rational thinking and follows the structure of study.

Thus, perfect prediction is either not possible or is only possible if restrictions are imposed on the thought of the players involved. Doing so, denies the problem of all aspects of reality. This logic converts the Operations Research modeling problem into one of simulation and gaming based upon a probability that the expected outcome will occur.

This indeterministic aspect of Operations Research reduces its reliability for predicting the future. However, with expanded computer technology, the ability to feed in thousands of variables and constraints, enables the operations researcher to approach, more closely, the probable outcome in reality.

Given the large personnel turnover in the military, it is extremely difficult to maintain coordination, comprehension and control over large models and simulations. Many models have not been conceptually based and have not reached their fullest potential.

#### Contribution of War Games

Martin Shubik presents a critical look at military war gaming in his book.<sup>6</sup>

Military gaming is extensive. It appears to be here to stay. Yet, in spite of the growth in activity there does not appear to have been a commensurate expansion in an organized body of knowledge. Many war gaming problems are intimately linked to game theory, to human factors analysis, and to the social psychology of risk behavior . . . Yet the war gaming operational and teaching activities appear to scarcely contribute to or learn from activities other than a certain amount of human factors experimentation.

Specific changes in the use of Operations Research techniques need to be

made for the future. Among these changes include objective measures, predictability and delineation of purpose.

Notwithstanding their tremendous utility in evaluating competing strategies, tactics, and military hardware, war games are not easy to use. With current pressures to improve the quality and comprehensiveness of war games, the process of translating the desired actions into a meaningful form is growing more difficult.

Two different scenarios, one in Europe and one in the Middle East, are presently in the Army War College core curriculum. Others are used in the advanced courses (electives). Two and one-half days are allotted for the play of each game. Only one day is required to train the students in the mechanics of playing each war game. This is amazingly fast considering that most of the students have limited experience with the computer. But, it is not fast enough. The purpose of war gaming in the curriculum is to enhance the students' professional development by providing them with an opportunity to test the military strategy, planning, and operating concepts that they have learned.

Thus, more time needs to be devoted to using war games, and less time to learning how to use them. This problem is not peculiar to academic institutions. In analytical agencies where the war games tend to be larger and more complicated to use, military and civilian analysts are often assigned to a new model, a new job, or a new agency shortly after they become conversant with their current war game.

The primary advantage of computer-assisted war games over field experiments and large-scale war games in the field is that they are faster, less expensive and easier to manipulate. Some war games already require several months to simulate a few days of division-level combat. If current trends continue, war games will become even slower

and more expensive, thus losing some of their utility.

The interactive war game under development at the Army War College to simulate theater-level combat solves the increasingly complex input problem by permitting "free-form" inputs. Inputs which are out of sequence, not in the proper column, or missing a decimal point do not destroy the game. Instead, the input line is scanned looking for keywords which the computer recognizes. When insufficient information is presented in an order, the computer asks for more. Instead of being cryptically encoded in a series of numbers, input to this war game is much like English. The following lines are examples of valid inputs:

MOVE B107 TO CC51 AT 20 MPH START NOW  
START 11.50 HOURS TO CC51 AT 20 MPH B107 MOVE  
R116 MOVE TO DD52

AIR ON DD54 FROM B701 45 SORTIES  
AIR FROM B701 - 45 SORTIES ON DD54  
45 SORTIES AIR ON DD54 FROM B701

RESUPPLY B651 WITH 50 TONS OF POL  
55 TONS AMMO TO RESUPPLY B651

These very flexible, English-like commands will reduce, to about an hour, training in the mechanics of playing the war game, thus allowing more time for using the war game. The same commands can be used for any part of the world, so no retraining will be required to move from the NATO to the Mid-East War Game.

Theater models tend to inundate the gamers with more information than they can possibly handle, just as a real theater commander is flooded with information. Yet at 30 characters per second, it is presently impossible for a terminal to keep up with all of the important events in a theater, especially if the simulation is running faster than real time. Computer graphics, however, can rapidly draw and redraw the entire theater map or any portion of it and the location of all units.

This information can be displayed on a TV tube, on a large-screen display (6-foot or larger TV projector), on an electrostatic printer, or on a plotter capable of drawing full-size overlays.

By means of digitizing tablets, computer graphics hardware can provide an alternative to free-form inputs. Maps can be placed directly on top digitizing tablets which are available as large as 42 inches by 60 inches. Then, to move a unit on the battlefield, simply touch the unit with the pen provided and touch its destination on the map.

New voice synthesizers and voice recognition devices open new possibilities for the future challenge. Already using an English-like language for typing commands, now these commands can be spoken into the computer. Relatively inexpensive voice recognition devices capable of recognizing up to 64 different words are currently available for personal computers. These personal computers can be tied into existing large-scale computers and graphics peripheral equipment. Such a system would represent a closer step to reality for the input-output process. War game results also could be presented in three ways—by a computer synthesized voice, graphically, or on a typed page. Such a system would allow maximum two-way transfer of information to and from the computer while making the interface between man and machine more transparent.

The projected picture for the future of war gaming is actually infinitely limitless for the Armed Forces. Pure Army problems are no longer separable into neat, tidy packages. Under current trends most Army problems are composite military operations intrinsically entangled with social, cultural, economic, and political factors at home, and abroad. Military art has become more analytical requiring the management science resulting from ORSA. With the change, the computer is the



fast reliable automaton, a process controller, an information processor, and a decisions selector.

Decision-making in the Armed Forces will become increasingly more dependent upon ORSA and less on experience. Even the experienced manager must couple his experiences with new methods and accept complexity in order to keep pace with the modern order. Management personnel in the Armed Forces are becoming increasingly aware with better education and training; hence, they tend to place a greater emphasis on quantitative scientific methods and logical analysis.

#### The Need for Advanced Technology

Objectives of the High Technology Light Division Study include:

- (1) Develop an analytical basis for evaluating variations of the HTLD.
- (2) Develop analytical methods to measure the effectiveness of and compare various organizations.
- (3) Analyze various organizational options within the HTLD to develop a preferred division structure.
- (4) Compare the base case HTLD with DIV 86 and the C-series ID.
- (5) Recommend the organization of the HTLD on the basis of combat effectiveness, strategic deployability and cost.

Organization for the dynamic advanced technology battlefield is shown by Table XVIII.

TABLE XVIII

## ORGANIZATION OF DYNAMIC BATTLEFIELD

AREA	CONCEPT OF OPERATION	ROUTINE FORCE ASSIGNMENTS	COMMAND AND CONTROL
Deep Battle Area (15-70 KMs)	<ul style="list-style-type: none"> <li>o Fight as Deep as Possible</li> <li>o Degrade Enemy CBT Effectiveness</li> <li>o Strip Away Enemy Recon</li> <li>o Mass at Critical Points</li> <li>o Deep Attacks</li> </ul>	<ul style="list-style-type: none"> <li>o Maneuver               <ul style="list-style-type: none"> <li>- CBAA</li> <li>- Light Atk Units</li> </ul> </li> <li>o Fire Support               <ul style="list-style-type: none"> <li>- Rocket Arty</li> <li>- Air Defense Arty</li> <li>- USAF</li> <li>- EW (Deep Spt)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>o DTOC</li> <li>o Fwd Opns &amp; Plans Center</li> <li>o ADC-O</li> </ul>
Near Battle Area (0-15 KMs)	<ul style="list-style-type: none"> <li>o Contain Enemy Strength with Minimum CBT Power</li> <li>o By-Pass Enemy Strength</li> <li>o Achieve Decisive Results at Enemy's Weak Points</li> <li>o Flank/Rear Attacks</li> <li>o Prevent Envelopment</li> </ul>	<ul style="list-style-type: none"> <li>o Maneuver               <ul style="list-style-type: none"> <li>- Maneuver Bdes (0-15 KMs)</li> <li>- Maneuver Bns (0-5 KMs)</li> <li>- LT MTZ Unit</li> <li>- Assault Gun Units</li> <li>- CBAA/Light Atk Units Reinforce</li> </ul> </li> <li>o Fire Support               <ul style="list-style-type: none"> <li>- Cannon Arty</li> <li>- Air Defense Arty</li> <li>- USAF</li> <li>- EW (Fwd Spt)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>o DTOC</li> <li>o Command Ctr.</li> <li>o CG</li> <li>o TAC CP (Option)</li> </ul>
Rear Battle Area	<ul style="list-style-type: none"> <li>o Neutralize Enemy               <ul style="list-style-type: none"> <li>- Envelopments</li> <li>- Flank Attacks</li> <li>- Penetrations</li> <li>- Infiltrations</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>o Maneuver               <ul style="list-style-type: none"> <li>- CBAA</li> <li>- Light Atk Units</li> </ul> </li> <li>o Fire Support               <ul style="list-style-type: none"> <li>- Rocket Arty</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>o DTOC</li> <li>o Rear Opns &amp; Spt Ctr</li> <li>o ADC-S</li> </ul>

TABLE XVIII (Continued)

AREA	CONCEPT OF OPERATION	ROUTINE FORCE ASSIGNMENTS	COMMAND AND CONTROL
		- Air Defense Arty - USAF - EW (Deep Spt)	
Logistics Battle	o Project and Main- tain Sustaina- bility System o Spt Fluid Opns On Porous Battlefield o Prepositioning o Reconstitution	o DSA Units o BSA Units o Fire Spt Coordi- nation Capability	o HTLD Rear Elm o DISCOM CP

#### Dominating the Battlefield of the 21st Century

The Army can successfully accomplish the worldwide contingency missions postulated for the Year 2000 by exploiting the potential of high technology. To do this requires a sophisticated understanding of strategy and operational art.

The following areas must be continually assessed:

- (1) The conceptual underpinnings of strategic thought required for anticipated global contingencies.
- (2) Current future plans in terms of appropriateness for turn of the century missions.
- (3) The institutional framework and systemic processes which currently govern the rate and quality of the force structure relative to their effectiveness and efficiency.

The viability of the Army at the turn of the century will depend upon revolutionary shifts in traditional Army approaches and philosophies of warfare. Some of these revolutionary initiatives are:

- (1) Development of force commonality and modularity.
- (2) Advanced education programs beyond the Masters Degree for

Army Officers.

- (3) Establishment of direct interfaces with the technological - scientific - academic communities.
- (4) High technology force structure.
- (5) Realignment of Army doctrinal development to take greater account of both history and technology.
- (6) Development of multi-skilled technological oriented soldiers.
- (7) Greater emphasis on joint-integrated battle simulation arrangements.
- (8) Extended periods of service and stabilized career programs.

GETTING INTO THE FUTURE NOW REQUIRES BECOMING A PART OF THE RAPID CHANGES TAKING PLACE. TO GET ON TOP OF THIS, TO DOMINATE THE FUTURE BATTLEFIELD, REQUIRES NOT ONLY BROAD-BASED CREATIVE THOUGHT PROCESSES BUT A BELIEF IN MANAGEMENT SCIENCE. SUCH A BELIEF MUST BE WELL BEYOND A SUPERFICIAL UNDERSTANDING OF THE TECHNIQUES INVOLVED. THE CHALLENGE LIES IN DEVELOPING AN APPROPRIATE BLEND BETWEEN THE ART OF LEADERSHIP AND THE SCIENCE OF MANAGEMENT.

## CHAPTER VII

### ENDNOTES

1. Klaus Knorr, Military Power and Potential.
2. Lynn H. Rumbaugh, A Look at U.S. Army Operations Research--  
Past and Present, p. 14.
3. Senator John O. Pastore, "Thinking Factories," US News and  
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4. Donald L. Harnett, Larry L. Cummings and G. David Hughes,  
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5. Russell L. Ackoff, "The Future of Operational Research is  
Past," Journal of Operational Research Society, p. 93-104.
6. Martin Shubik, Games for Society, Business and War: Towards  
a Theory of Gaming, p. 294.

## CHAPTER VIII

### CONCLUSIONS AND RECOMMENDATIONS

The complexity of problems that the Armed Services face in this last part of the Twentieth Century can only be solved within the highly scientific and specialized man-machine environment of Operations Research/Systems Analysis. The socioeconomic, political, and cultural factors creating present and future military problems also produce the same impact upon business and the industrial base. The challenge of the future of Operations Research/Systems Analysis is one of enormous diversity and unlimited horizons in which the creative leader can develop new machine systems and advanced programs for decision-making.

#### Summary

Many of the conclusions and recommendations from past studies are still applicable today. The simulation of modern systems imposes demands for an increasingly well-educated and imaginative leadership. Also required are closer links between the military and the technological-scientific-academic communities. Longstanding areas of need linger on. There are continuing needs for: better data; more statistical analysis; greater understanding of the impact of human factors on the future battlefield; highly developed informational networks within the modeling community; and, integrated management structures for study and analysis.

War gaming applications will continue to be developed along with the advanced practice of Operations Research. As more is learned about techniques for realistic simulated experience, more sophisticated models will be utilized in order to better assess threat environments.

Decision-making capabilities will also increase with continued use and improvement of modeling techniques.

Future predictions will become more closely aligned with actual events as analytical techniques are refined. Limitless possibilities will abound as the Military becomes more involved and more invested in the art of Operations Research model building.

#### Conclusions

Too often the need for a model is poorly defined. The modeler is often left to his own devices to scope the work. A clear statement of the requirement is an essential first step in model building. Requirements must be derived from concepts and represent a set of clearly stated issues against functional area descriptions. It is a tedious process to develop issues and then decide how much functional area resolution is needed to capture the essence of a process or activity.

The Army needs a formally established structure to develop and exploit future issues. Current analytical support to the HTLD is not robust enough to handle the HTLD concepts. Models cannot represent everything for everybody; they must be tailored for vital decision issues and modified to meet specialized study requirements.

The Army study and analysis community is decentralized. The MACOMS and analytical agencies have enormous latitude in focusing analytical resources. HQDA could provide more direction on the central issues in order to work on models today to meet future needs. The options for

model development range from a quick, "good enough for government work approach" to one that uses a top-down structured design. In the former case, the emphasis is to get the model running quickly regardless of its shortfall. The latter approach is structured and drives off a clear user requirement statement to develop preliminary and initial design specifications before the coding process begins. Many argue that the structural approach is most efficient.

When model development goes beyond attrition the interactions of maneuver, firepower, intelligence fusion, support and C<sup>2</sup> forms a gestalt that defies a simplistic, piecemeal approach. It does not make sense to build a model that represents everything in great detail. The present technology is not responsive enough to insure that such models will not fail, either in development or in execution. The challenge is to extract the essence of processes from a selected, specified portion of reality. This calls for close coordination between all of the various agencies involved in building and using Army models.

With the increased modeling scope, the need for data has expanded tremendously. This data ranges from item system performance to function performance, environment considerations and extensive decision logic. Data voids can be filled by a directed effort to mass the resources of organizations such as OTEA, CDEC, NTC, units, national laboratories, OGSC, and the war colleges. Many data shortfalls are unique in that we are prohibited from doing essential testing to gain necessary insights.

The Army does not yet realize the importance of Artificial Intelligence (AI). The Army Science Board has begun investigating this area; however, most applications are considered against robotics. In the modeling area, AI offers enormous opportunities to automate complex



decision logic in simulations and analytic models. AI can be used to speed up war games by automating many routine decisions now left to gamer interaction. As more C<sup>2</sup> and intelligence is programmed into models, AI techniques like pattern recognition, knowledge base and expert systems techniques can assess the perceived state of the battlefield against the commander's desired state. Then, criterion-based decisions may be determined from among alternative courses of action. While this advanced technology is impressive, it does not release the Army from front-end analysis of key parameters for criterion-based decision logic. It calls for futuristic thinking and judgment well in advance of specifying a model architecture or writing code.

The CSA recently advised the AMIP developers to build in a capability to do force-level, corps/division level operational planning. He is concerned that modeling has focused on combat development and system acquisition. GEN Starry has the same concern at REDCOM; an analytical capability to analyze the development, employment, and sustainment of contingency forces.

Actions are needed in the eighties to get to the year 2000 with some success of exploiting high technology. The Army needs to formally constitute a group of futuristic thinkers covering all functional areas.

Technology breakthrough must be captured in the following areas:

- (1) Computer and graphics capabilities
- (2) Artificial intelligence
- (3) Distributed processing
- (4) Data Base Management schemes

There is always a tendency to attempt modeling in great detail. The art of the process is not in complex modeling but in the ability to tailor a model to a very specific purpose. With revolutionary changes

on the battlefield, modelers usually are locked into an evolutionary model development approach. Changes in modeling can be anticipated by long-range study and planning. The modeling community must put players in front end concept development schemes in order to gain timely analytical support.

#### Recommendations

The following actions are recommended:

- (1) Create a cataloging element within the Army modeling community in order to produce an annual, comprehensive catalog of models used by the Army. Include a catalog section devoted to review and analysis.
- (2) Establish time-oriented objectives for Army and DA civilians involved with modeling activities for attendance at professional conferences such as those held by ORSA/TIMS. Require minimal attendance standards per year.
- (3) Establish proactive components in all organizations directly involved with modeling activity. Include in their charter, responsibilities for close liaison between model developments and force modernization processes. Also include responsibilities for examination of High Technology issues such as Artificial Intelligence for application to Army Models for future combat.
- (4) Create a HQDA element for coordination and management of all Data Base issues required for Army Models.
- (5) Expand the AMIP internal structure and continue support in order to achieve an initial test of the Army Models Hierarchy by the end of 1983. Plan for wide dissemination of results.
- (6) Use selected portions of the Brewer and Shubik survey

form for the TRADOC Model Inventory shown by Appendix A to TRADOC Reg 5-4, Management of TRADOC Models (DRAFT).

(7) TRADOC, in coordination with CAC, accomplish an extensive, comprehensive study and survey for the separate publication of Modeling terms and definitions.

(8) CAC, in coordination with TRADOC, conduct an annual "CAC War Game Week" orientation and seminar for newly assigned senior officers, selected individuals in the Army Modeling Community and guests from the scientific-academic communities. Such a seminar would foster coordination and communication in the analytic community as well as meet TRADOC requirements for the continuing education needs of senior Managers/Decision-makers.

(9) Include all TRADOC models, regardless of size, under the purview of TRADOC Reg. 5-4. Structure a coordinating link between the AMC and the TRADOC Models Committee.

(10) Continued development and enhancement of MTM by the Army War College and other users. Allotment of more time for MTM instruction and play for USAWC students.

(11) Increase official publication of model documentation by all Army activities responsible for models. Encourage additional publication of an informative nature in the open literature e.g., Journal of the Operations Research Society of America. Adopt formal guidelines and standards for reporting study results.

(12) DUSA(OR) re-examine charter and expand guidance and direction to Army Modeling efforts. Include design for future priorities and specific actions.

(13) Establish standards, methodology and formats for exter-

nal, periodic review of all Army Models. Initial actions could be undertaken by the SPMO or the Army Models Review Committee to allow for involvement of review members from the academic-scientific community.

(14) Maintain decentralized control of models throughout the Army, to foster creativity and individual model tailoring, but require specific coordination actions, centralized management direction and data base control. Such actions must originate at CSA, VCSA or DUSA(OR) levels.

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## APPENDIX 1

### MONTE CARLO TECHNIQUES

The development of Monte Carlo techniques has a lengthy history. There is some disagreement regarding appropriate terminology. Harling, for example, suggests that "simulation" is to be preferred to "Monte Carlo" since the latter term suggests limitation to statistical sampling experiments and the former implies a more inclusive stochastic model.<sup>1</sup> General practice, however, does not tend to make this distinction. Teichroew suggests that simulation is an extension of distribution sampling practiced by statisticians since the turn of the century and provides an extensive bibliography of early studies.<sup>2</sup> Investigation of Monte Carlo techniques thus preceded, by quite a while, the origin of the term. Buffon's needle problem and Lord Rayleigh's "random walks" are examples. Current development is attributed to the work of von Neumann and Ulam during World War II on neutron diffusion. The paper by Metropolis and Ulam coined the term "Monte Carlo" and is considered to be historically significant.<sup>3</sup> Their approach, still an application of Monte Carlo, was essentially a statistical one applied to integrals and differential equations. The development of Monte Carlo techniques has been enhanced by the concurrent development of computers so that it is now relatively simple to apply to a wide range of war gaming situations.

Monte Carlo simulation consists generally of transforming random

variables to variates of selected density functions based on observed data, e.g., weapon system characteristics. General discussions are in Amstadter<sup>4</sup> and Brown,<sup>5</sup> with more detailed treatments in Chorafas<sup>6</sup>, Fabrycky,<sup>7</sup> and Buslenko et al.<sup>8</sup>

Monte Carlo is also described in much of the literature of operations research. Chase and Aquilano<sup>9</sup>, Bierman, Bonini, and Housman<sup>10</sup>, King,<sup>11</sup> and Buffa<sup>12</sup> give methodologies and sample applications, especially to queuing problems. In reliability studies, Thoman, Bain, and Antle<sup>13</sup> and Nancy R. Mann,<sup>14</sup> have used Monte Carlo for work with the Weibull distribution. Complex systems are treated by Curtin<sup>15</sup> and Gilmore.<sup>16</sup>

Since Monte Carlo techniques require a source of random numbers, the problem of their generation appears frequently in the literature. Three methods have found favor. The first, and earliest to develop, is tables of random numbers which have been subjected to statistical tests for randomness. The RAND Corporation, for example, in 1947, generated 10<sup>6</sup> random digits from a physical source. The use of tables, however, is generally unsuited for use with computers. Von Neuman and Metropolis proposed an alternate means of generating random numbers, which is described by Haugen<sup>17</sup> and Chambers<sup>18</sup>. This method, however, has faults also and has been superseded by methods which are more rapid and economical for computer use.<sup>19</sup> A commonly used method originally developed by IBM for their subroutine package, RANDU, is described by Schmidt and Taylor.<sup>20</sup> Once a random number is generated it is then necessary to transform it to a variate based on the distribution being considered. General discussions of transformations are given by Kozlov<sup>21</sup> and Hershkowitz<sup>22</sup> as well as several of the bibliographic references. Many of the various techniques may be employed in the development of war game

situations in order to provide more realistic simulations of the various aspects of the modern battlefield.

## APPENDIX I

### ENDNOTES

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## APPENDIX 2

### MODELS

A model attempts to portray something without completely being the thing itself. Models are used to aid understanding of an actual event or possible occurrence. Models can be symbolic, such as mathematical portrayals of actuality. They can also be analog, such as scale models and "mock-ups." A model can be constructed to combine portions of actuality with simulated (or modelled) portions of reality. Such is the case with a war game that uses actual players to make decisions based on a simulation (model) of realistic events.

In the case of past events, models can be developed that completely explain selected aspects of the event. This is the case when the past event is well known. The term "realistic" is used when dealing with future events since reality can only be known as a current or past event. Even with historical events it is often difficult to find common, wide-spread descriptions of relevant reality.

Single mathematical equations are examples of simple models that are very often so based on reality that their use to explain potential future reality is highly accurate. Many relationships such as these are found in the "hard" sciences. As models increase in their degree of complexity and inclusion of the human dimension, the accuracy of results becomes more a matter of judgement. Were all of the relevant variables

accounted for? Was there a realistic relationship between the variables?

Models are used for many purposes. Many are used to examine selected aspects of a posed or real situation in order to explain or to predict events. Models are also used for educational and recreational purposes. They are most applicable when it is either impossible, infeasible, or too expensive to replicate reality. As abstractions of reality models attempt to represent those aspects of the real world which are judged to be most applicable to the issues under examination.

In the Army, models range from extensive field exercises to concise mathematical statements used to examine a specific weapon. Their purpose includes training, testing of plans, analysis of force structures and evaluation of weapon systems. Specific models have also been developed for logistics, electronic warfare and many other subsets of the modern battlefield.

### APPENDIX 3

#### OPERATIONS RESEARCH VERSUS SYSTEMS ANALYSIS

Only subtle differences exist between the terms Operational Research (OR) and Systems Analysis (SA).<sup>1</sup> The demarcation is a matter of degree; thus, the terms are often used interchangeably or simply as ORSA. The definitive usage of the terms is left to the group or team engaged in a particular analytic activity.

Basically, OR is more concerned with mathematics or logical thought processes backed by careful observation and methodical analysis. For rational decision-making, the right answers must be provided at the right time. Often, OR is used to increase the efficiency of a man-machine system in a situation where criteria for efficiency has been specified. Frequently, a computer model is relevant to the case. OR derived from scientific activity which was firmly grounded in the success of the scientific method.

Systems Analysis, on the other hand, is more complex than OR, because it deals more with what should be done to the establishment of objectives, models, costs, alternatives, and criteria. It thus represents more of a normative, intellectual activity. The key to successful analysis is in the complex and continuous cycle of formulating the problem, selecting objectives, designing better alternatives, and examining feedback data. These various alternatives are usually exa-

mined by means of models. The models help to explain various elements to include costs. The measures of effectiveness tell to what extent each objective is attained. A criterion can then be used to weigh costs against performance and, thus, give priorities to the alternatives.

Systems analysis may be considered as a purely intellectual approach to decision-making -- a coldly objective method free of bias, judgment, and intuition.<sup>2</sup> However, judgment and intuition are used in designing models. Also, judgment is used in deciding on relevant factors and their inter-relations. Hence, many elements of the unknown are contained in certain variables which may be seen to exist in systems analysis. It is well to keep them in mind when considering the "factual, statistical, error-free" data offered by the systems analyst or operations researcher.

First introduced in World War II studies, systems analysis stems from weapons analysis. In related literature, it may be referred to as Systems Research, Systems Design, Systems Engineering, and even as Systems Research.<sup>3</sup>

### APPENDIX 3

#### ENDNOTES

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## APPENDIX 4

### MODELING DEFINITIONS

1. Analytic Model. A set of expressions that generally aggregate the actions they examine by means of mathematical relationship. They can often be utilized by the analyst at his desk or with minimal computer support.
2. Color Graphics. A display in color of an event occurring within an automated or partially automated war game.
3. Computer-assisted Game. A manual game utilizing digital computer assistance for bookkeeping and damage assessment. Also called a manual-computer game.
4. Data Base. A single source with all data required by a model.
5. Educational Game. A game conducted to provide military commanders or executives with decision-making experience, and to familiarize them with the operations and problems involved.
6. Force-on-Force Model. The depiction in a model of a two sided military engagement which plays the principal factors having an influence on combat.
7. Functional Model. The depiction in a model of a two sided military engagement in which only one functional element of combat is considered in detail.
8. Game. A physical or mental competition conducted according to rules with the participants in direct opposition to each other.
9. Game, Closed. A game in which the player has only such knowledge of his own and his opponent's situation as is transmitted to him from the game control group.
10. Game, Computer. A simulation of a competitive situation carried out completely on a computer in which the only human intervention is by the players themselves issuing orders.
11. Game, Free. A game in which the results of interactions between opponents are determined subjectively by the control staff on the basis of experience and judgment.

12. Game, Free-play. A game in which the player is free to make any tactical decisions he desires consistent with his resources and the game objectives.
13. Game Parameter. A measurable condition which is assumed to be constant with respect to game time.
14. Game Theory. A mathematical theory concerned with the choice between alternative courses of action by opponents, where the outcomes can be specified mathematically.
15. Hardware. Computer equipment necessary for program (software) input, transformation and output.
16. Input-Output Device. A device peripheral to a computer which provides either for input to the computer, or output in graphic, audio or printed form.
17. Input-Output Terminal. A special term used for the point of man-machine interface.
18. Level. The range of the echelons of military command which are represented by the players in a war game. Also, the lowest echelon of command which is represented by players.
19. Level of Game. The largest formation on the side of principal interest whose play is required for the objective of the game.
20. Methodology. The way that techniques and procedures are employed in a study or analysis.
21. Model. A representation of some thing, event or system.
22. Monte Carlo Method. The use of random sampling procedures for treating probabilistic mathematical problems. The sampling procedure may involve some variance reducing technique if the name "Monte Carlo" is given to it. Sometimes it is convenient in the process of a calculation to replace a deterministic situation by a related probabilistic one which is then treated by the use of Monte Carlo methods. (See Appendix 1.)
23. Operational Model. Models which deal with force effectiveness. They include analytical models and force-on-force models.
24. Performance Model. A model which examines the way in which a system discharges the tasks for which it was designed. Performance models may be one sided, or they may be two sided in which case they look at single systems against one or a few systems.
25. Play. A single run-through of a game, sometimes used also to represent replications of a game under a single set of starting conditions.

26. Player. A participant who represents or is part of a group representing one of the opposing sides in a game. In a war game, the players assume the roles of commanders and staff officers of military units or formations.
27. Post Processor. A set of logic which converts raw data developed by the computer into usable form by means of statistical applications, ordered groupings, charts, graphs and tables.
28. Reality. A concept that consists of an infinite number of interacting variable processes. Isolation of a selected number of these variables can be used to portray some part of reality that is considered important. Past events, if accurately observed and carefully recorded, can be modelled with greater accuracy than unknown future events.
29. Resolution. The basic units of force, distance and time used in a war game.
30. Resources. the total capabilities of each force represented in the war game, including logistical, manpower, firepower, mobility, communications, reconnaissance and command.
31. Routine. A major element of a model; an ordered set of instruction that has frequent use.
32. Rule. An objective statement of the results of any particular action or interaction between opponents in a game. This objective statement may be either deterministic or probabilistic in nature.
33. Rule, Deterministic. A rule which states precisely and uniquely the results of any particular action or interaction between opponents.
34. Rule Probabilistic. A rule which states the results of any particular action or interaction between opponents in terms of a probability-density function. the precise result which is to be applied on a given occasion in a game is determined by sampling randomly from this distribution. (e.f. rule, deterministic.)
35. Scenario. The structure of a war game, giving location, size, and development of forces, doctrine to be used, environments and military tasks to be accomplished by each side.
36. Simulation. A technique used to study and analyze the operation and behavior of man-machine systems in terms of the elements of which they are composed. It uses as a basis an imitation of reality which may include one or more of the following: (a) physical (including mechanical or electrical) model, (b) mathematical or symbolic models, and (c) human operations. These are inter-related (and manipulated) in such a way that there is correspondence with relevant characteristics of the "real" system under study. Conclusions about this system are then drawn by analogy.



37. Simulation, Deterministic. A simulation in which the outcome is predictable and the element of chance absent.
38. Simulation, Probabilistic. A simulation in which the outcome is subject to chance variations. Also known as stochastic simulation.
39. Starting Conditions. Instructions and information issued to players to initiate play of a war game. These usually include a statement of the mission to be achieved, forces available, boundaries, intelligence appreciations, and so on. Also called game directive.
40. Subroutine. A program which can be stored in the main or auxiliary program of a digital computer and used as part of other programs to perform a specific operation; e.g., a square root subroutine.
41. Training Model. A model which is exercised as part of a training program or course. The trainee interacts with the model, inputting guidance and receiving from the model combat results from the operation of his guidance on model logic.
42. Training Simulation. The generic term for an interactive vehicle-manual or computer supported - through which command and staff elements are trained in the performance of battlefield missions.
43. War. A state of armed hostile conflict between opposing forces for a particular end.
44. War Game. A simulated battle or campaign to test military concepts such as the operational art. Usually conducted with two-sided representation.
45. War-Game. To plan or conduct in the manner of a war game.

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